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GEOLOGICAL SURVEY OF KENTUCKY.

N. S. SHALER, DIRECTOR.

BULLETIN

OF THE

KENTUCKY GEOLOGICAL SURVEY.

NUMBER 1.

YEOMAN OFFICE—E. H. PORTER, PUBLIC PRINTER.

INTRODUCTION.

The Geological Survey of Kentucky has, in a natural way, become a bureau of information concerning the economical resources of the Commonwealth. In following the several lines of inquiry to which it has been directed by the successive enactments of the Legislature, it has been compelled to concern itself with a great variety of topics, some of which can only be brought under the head of geology by giving to that word a much wider meaning than is commonly assigned to it.

An examination of the tables of contents of the several volumes of Reports and Memoirs already published will show that, besides the principal topics of a purely geological nature, having an immediate bearing upon the mineral resources of the Commonwealth, there are many Reports concerning the Metallurgy, Agriculture, Manufactures, Forests, Topography, Fossils, &c., &c., all of which are pertinent to the various inquiries which must be made in a general survey of a State. The practice of the Survey has hitherto been to publish these results in separate preliminary Reports, the results of which are hereafter to be embodied in a Final Report. Experience has shown, however, that there is a need for a more immediate means of publication than these Preliminary Reports can afford. Almost every day brings to light some facts concerning the structure of the rocks of this district, the nature of their resources, or other noteworthy matters that are in themselves too limited to be dealt with in the deliberate fashion of Special Reports, yet merit immediate publication. It has, therefore, been determined to begin, in the form of this pamphlet, a publication which shall give place to this class of contributions. Much of the matter that is here given will afterwards be embodied in the permanent publications of the Survey, and all that which is of permanent value will find its place in the Final Report on the Geology of the State.

The subsequent numbers of this Bulletin will appear from time to time, at irregular intervals, when the matter on hand may appear to justify the issuing of a number in the series. At the end of the article that attains the five hundredth page, the volume will be closed and another begun. Each volume will be indexed separately, and the con-

tents of this volume, at least, will appear in the general index of the publications of this Survey, which is now in preparation.

The publications of the Survey consist, in the main, of Reports of Progress. These are divided into two series, of which the first, consisting of four volumes and an atlas of plates, was published under the direction of the late David Dale Owen; the second, consisting of four completed volumes and parts of two incomplete volumes, has been published by the present Director. The first series was not stereotyped, and is out of print. The second series is stereotyped.

In addition to these Economic Reports, one volume of Memoirs has been published under the present direction, and a second volume is well advanced in preparation. A series of photographs of the Commonwealth has been begun, and the first series of one hundred plates, printed by the autotype process, is now ready for publication.

A complete index of all the existing publications of the Survey has been prepared, and will be published as soon as the fifth and sixth volumes of the Preliminary Reports and the second volume of the Scientific Memoirs are completed. It will make a separate volume of about five hundred pages, giving a complete and well-arranged key to all the publications of the Survey, arranged by subjects and by counties.

PETROLEUM.

BY N. S. SHALER.

While I desire to leave the consideration of all the theoretical questions to the less-limited space of my Official Reports, it will be necessary for me to preface the few practical suggestions which I desire to make by some general statements concerning the history of oil-bearing deposits. Out of the great mass of well-digested facts concerning the conditions of petroleum, which have been given to science through the labors of practical geologists, I shall only select a few very noteworthy truths which have especial bearing on our problems encountered in Kentucky. In these general considerations, I shall confine myself to the following points: First, as to the method of origin of our petroleums and related substances; second, as to the conditions of their storage in the rocks where we find them.

The Method of Origin of Petroleum.—It is now quite beyond question that our petroleum, bitumen, mineral wax, and other allied substances, are, quite as much as our coal-beds, the products of organic life, the only difference being that the coal-beds are altogether the result of vegetation that has grown, like our forests, in the air, while the petroleum and other bituminous deposits have their origin in the remains of the organic life, animal and vegetable, which had its being in the ancient seas. It is a well-known fact that any organic matter, such as wood and coal, as well as the tissues of certain animals, may, by simple chemical agencies, be, in part, transformed into oils. During the long ages when our rocks, which appear at the surface in Kentucky, were being laid down on the ancient sea floors, the sea-weeds and other living things of the ocean were heaping up their remains in the sandstones, limestones, and other deposits. Sometimes these deposits are so full of this waste of ancient life, that its whole appearance is affected thereby. The Devonian black shale, for instance, that thick deposit of dark-colored material, which is found a little above the line of the Blue or Cambrian limestone, seems to have been, in the main, formed by the long-continued depositions of sea-weeds on this part of the ancient

ocean bed. In most cases the process of decay has destroyed all distinct trace of the organisms whose remains have been built into our rocks; but the chemical combinations of matter brought about through their existence remain in the rocks long after all distinct traces of the creatures have vanished.

As far as the share of organic beings in the making of hydrocarbon compounds (coal, petroleum, &c.) is concerned, rocks may be divided into several groups, according to the amount of material available for conversion from organic matter to the class of substances akin to petroleum. First and highest among these in richness of matter suitable for making hydrocarbons, we must set the black bituminous shales, such as the Devonian shale, so well known along the northern side of Muldraugh's Hill. Next to these shales, the limestone deposits afford the greatest amount of substances suited to develop petroleum; and least rich in materials of that class are the sandstones and the conglomerates, *the very rocks that yield the most important supplies of petroleum which have yet been found.* This seeming contradiction we shall see through when we come to consider the conditions under which petroleum is preserved and yielded by the rocks.

While it is clear that the petroleums and related substances of our rocks are derived from the organic matter deposited with them, it is not by any means so clear to students of the question just how the changes which converted the remains of animals and plants into oil took place. A variety of theories have been framed, differing much among themselves; but it will not be possible to discuss these several views within the limits of this letter. They are all essentially alike in holding that certain changes, allied to fermentation, and at the same time to the alterations of matter that go on in a highly-heated gas retort, proceeding with great slowness in the low temperatures of our rocks, have generated the oils, gases, and other similar substances we now find in them. There can be little doubt that this process demands peculiar conditions for its activity. What these conditions are has not yet been determined, but they are common to the whole earth, and have been brought about in all lands, and at nearly every stage in geological history. All rocks laid down on the ocean floors which contain any considerable traces of organic life are likely to show the presence of these products of the natural laboratories. I am satisfied that the profitable occurrence of petroleum depends upon the rather rare conjunction of conditions which have not only favored the production of the substance, but have also at

the same time favored its storage in some fashion that would admit of its being drawn off in the way required by the needs of man. I believe the forces that produce petroleum are common, while the conditions that favor its storage and extraction are, by the rarity of their occurrence, the principal causes of the scarcity of its existence in profitable quantities. It is, therefore, of the first importance to consider the conditions that determine the retention of the petroleum, and its allied compounds, in positions favorable for their utilization.

Conditions Determining the Storage of Oil in the Rocks.—The first point to command our attention is, that while the conditions most favorable to the production of petroleum are found in shales and limestones, it is only in conglomerates, sandstones, or very sandy limestones, that the material has ever been found in very large quantities. I am satisfied that this is due to the differences in the texture or permeability of the several kinds of rocks. A limestone or shale deposit has few interstices; it is generally not easy to force more than one or two per cent. of water into the cavities of their mass. Where they are below the drainage of a country, and have never had underground streams flowing through them, they are generally quite without fissures. The fluids they contain are intimately blended and imprisoned in their mass. Our black shale, for instance, has ten or more per cent. of its bulk made up of petroleum, but this is firmly fixed within its structure by the close contact of the fine grains that make up the beds. In the process of generating the oil, there seems to have been a large collection of gas, which, in its long-continued escape, has driven the oil before it along such interstices and crevices of the shale as existed there, and so forced it onward beyond the beds where it originated, either to the surface where it would be washed away, or to the neighboring rocks where it might find better storage. This better storage would be afforded if, in either direction, above or below the point of origin, there was an open-structured sandstone or conglomerate. Beds of this character will often take five, ten, or even fifteen per cent. of their bulk of fluid into the interstices between their grains. It is true that before the invasion of the petroleum, these crevices would have been filled by water, but the oil is urged away from its point of origin by the very powerful impulse of the gases which are made with it and accompany its path. The tendency is to force the water before the oil, and so secure a place in interstices of the rocks. It may, in this fashion, often happen that in this struggle between these fluids for the possession of the crevices in the rocks near to seats of pro-

duction of oil, that the oil may obtain complete possession of extensive areas of storage.

There is yet another question of a general nature concerning the chemistry and geology of these bituminous substances which is still under debate. It is, whether they are still in process of generation within these rocks where we now find them? When we consider the continued loss that these substances have been subjected to, through natural springs, for an incalculable time, and at the same time note that the rocks whence they escape have at the present time all that they can store within their inter-spaces, we are forced to believe that it is still forming. This conclusion becomes the stronger when we consider that the rocks are continually yielding quantities of the gases which accompany the formation of petroleum. Thus, while there is still some doubt on this point, it may reasonably be supposed that the process which has created these valuable products is still going on in the rocks beneath our feet.

Practical Considerations.—Having now considered in outline the conditions of occurrence of petroleum, it will be possible to give a brief statement of some of our own economic problems with greater clearness and brevity than could otherwise have been possible. First, as regards the geological levels of these oils in Kentucky, counting downwards. These are four in number, as follows: The uppermost is that formed by the sandstone beds which are known as the Chester sandstone, lying between the top of the Sub-carboniferous limestones and the base of the true coal-bearing rocks. Next below we have the Waverly or Keokuk sandstone beds, which in Northern Kentucky are very sandy, but become in the main clayey deposits in Southern Kentucky, and in that section afford little oil storage. The third important line in the descending series is found just below the Devonian black shale, the coal black beds so common immediately north of Muldraugh's Hill. This third line of sandstone is the upper part of the blue limestone (upper Cambrian), which, in the region south of the Lebanon Branch Railroad, is changed to a blue-gray sandstone. Still further down we penetrate a bed of coarse sandstone, which is not shown at the surface at any point within the Commonwealth of Kentucky. This constitutes the lowermost oil level. On all these levels extensive traces of oil have been discovered; but all the oil as yet marketed from Kentucky comes, I believe, from the Cumberland sandstone, as it has been termed in the reports of this Survey, or the sandstone formed on the top of the Cincinnati divis-

on of the upper Cambrian. In a small part of the State there is a coarse, flinty, calcareous sandstone, lying just below the black shale, and possibly the equivalent of the Corniferous limestone. In Canada, and probably other districts, this rock has yielded much oil. So far as is known to me, this rock has not afforded any strong trace of oil in Kentucky.

I am satisfied that the limited yield of oil from a large part of the wells in our Kentucky field has been due in the main to the relatively extreme compactness of structure in our oil-bearing rocks, and not to the absence of the oil from deposits found within the State. I am, moreover, inclined to the opinion that the mistake in our explorations for oil has been in trusting to a system of small borings which, though a suitable means of exploring for oil in certain kinds of rock, is a method unsuited to our compact and little-fissured formations.

It is a curious fact that, while the methods of obtaining other sources of underground wealth have been greatly modified in their nature, according to the needs of particular localities, the search for petroleum in this country has always been prosecuted in the one way that happened to be successful in the oil rock district at the outset of the industry. Great changes in the mechanical appliances have been made, but the system of boring a slender tube, the walls of which are generally much compacted by the action of the boring tools, still prevails. The centuries' old experience in the oil wells of the Rangoon district, in British India, shows that there is another method of opening wells possible—one that I believe promises a great deal, if applied in our own fields. In Rangoon (Burmah), as in several other oriental oil districts, the oil is obtained through ordinary wells, exactly like those sunk for water. In a large part of our oil districts, these wells would not have to be over one hundred feet deep, in order to attain the oil-bearing rocks. The difficulties to be encountered, besides those met in ordinary well-digging, would arise from the gas which is found in company with the oil and the flow of surface water. Both these difficulties are avoidable. The gas can be blown out of the well by a simple fan; the ordinary fanning machine, with a cloth pipe reaching to the well bottom, will probably answer the purpose of making the air breathable; while the danger of gas explosions can be guarded against by using the Davy Safety Lamp, or by reflectors, so directed as to turn the sunshine down the shaft.

A well of this description would probably cost less than the bored well, and would give an indefinitely larger surface for the percolation of the oil. If desired, short, horizontal galleries could be carried out from the bottom, making the oil-yielding surface several thousand times as great as in the case of a bored well. I cannot help thinking that this form of trial promises much more than the further experiments with bored wells in districts where they have been already unsuccessfully tried. If the difficulty is, as I believe it probably to be, in the extreme compactness of our rocks, this change of plan is in the line of avoidance. Where the bored wells succeed, as I am glad to say it is proved they do in several countries, of course this change of plan is uncalled for. Where they have failed, and at the same time, a certain quantity of oil and gas have been obtained, I believe there is a fair chance of success on this simpler and older method of working by large shafts rather than by small-drilled openings. I would not advise its trial when the drill has failed to give any oil, and should doubt the result in case there was not an outflow of gas, for I believe it is to the gas we must look for the force that is to squeeze the oil through the pores of the rock to the opening of the well.

The areas within the Commonwealth where it seems to me worth while to search for petroleum are as follows, viz:

In the first place, we may exclude the whole of the so-called Blue-Grass district, or that region where the soil is immediately underlaid by rocks of the Silurian or Siluro-Cambrian age, except the narrow strip along the Cumberland, where these rocks appear at the surface.

In the remaining area of the State the probabilities of success are determined in part by the results of previous borings and in part by general considerations of structure.

I am inclined to believe that the region adjacent to the lower waters of the Big Sandy has no rich oil-bearing rocks very near the surface. A well at Peach Orchard, on that river, failed to yield oil in profitable quantities, though it was sunk to the depth of over a thousand feet, entering, to a considerable depth, into the Waverly or Keokuk series of rocks. I am more hopeful of success in the region of the upper Kentucky river. The rocks that underlie the coal-field dip rapidly to the southward, from a point near the east and west line, that passes through Peach Orchard, and do not begin to rise again until we pass the line between Kentucky and Tennessee. They are uplifted on the west by the long ridge, known as the Cincinnati Axis, which brings

the Blue limestone to the surface, and on the east by the sharp ridge, formed by the Pine Mountain fault and the Cumberland Mountain; so that, as a whole, the coal-bearing district of Eastern Kentucky is geologically a great trough, extending from near the Ohio river to near the southern line of Tennessee, where it borders on Alabama. This trough is diversified by several ridges and faults inclosed within its area, but it is essentially a boat-shaped depression of the rocks, with its central part, at its deepest point, about fifteen hundred feet below its eastern and western walls. This shape is very favorable for the retention of petroleum, and there is little doubt that, at sufficient depth, considerable stores of this substance will be found there. I do not think that in this area any of the promising horizons where petroleum may be expected to occur have yet been entered, save, perhaps, at the Goose Creek Salt Works; and there it is certain that the borings have not penetrated to the level that has produced the oil of the Cumberland district. I regard the deeper parts of this basin as the most favorable region for further exploration that this country affords. On the eastern side of this great trough, adjacent to the Virginia line, there is another more limited basin, which is inclosed between the Cumberland and the Pine Mountains, having a length of about one hundred miles between Pound Gap and Big Creek Gap, in the Tennessee. The rocks that underlie this basin are exposed on its eastern edge, and they give us fair promise of the existence of petroleum deposits within its area. Here the Ohio black shale (Devonian) is very thick and rich in oil, and we have below as well as above it some sandstones of a fairly porous nature.

Next to this eastern basin, we may look with hope to the region beneath the western coal-field. It is to be remembered, however, that the Ohio shale (Devonian)—that very oily deposit lying a little above the top of the Blue and Cambro-Silurian limestone—fades out as we go westwardly, and is very thin in most of the region to the west of the Louisville and Nashville Railroad. The oil section of the most importance that we may expect to find beneath the western coal-field is the lowest of all these that have been found in this country, viz: the Cambro-Silurian. So far, this horizon has never been penetrated by any wells bored in this section. The possible oil-producing beds will lie at a very considerable depth beneath the base of the coal-measures.

It does not seem likely that we shall ever find in Kentucky such large stores of light oils as have been discovered in West Virginia and Pennsylvania; but it is already certain that the Cumberland river district

abounds in heavy oils of a far more valuable quality, and there is good reason to hope that a careful search, with suitable means, will develop other districts of equal richness.

Within a few years it has been ascertained that the black shale of the Devonian age abounds in gas valuable for illuminating and heating purposes. In several towns in the neighborhood of Lake Erie this gas has been extensively utilized, and some use of it has been made in Southern Ohio. There are, at least, two distinct horizons in Kentucky where this gas exists in considerable quantity. In the Devonian shale and in the level of the Potsdam sandstone, which lies immediately below the level of the Cambro-Silurian or Blue sandstone, almost every boring that has penetrated two hundred feet below the level of this last named deposit has developed a large quantity of this gas, and in the Devonian shale the quantity found is generally large, and it seems pretty certain that a proper search for this gas will develop it in sufficient amount to make it of much value in the arts. A boring made twelve or fifteen years ago on the banks of the Ohio, just below Covington, gave a supply that lasted for years, and was so abundant that it became a source of danger to the distillery near which the well was situated. With some difficulty the well was closed, so as to prevent the further escape of the gas. If this supply could be obtained for the glass-works a mile further up stream, it would, I am informed, be worth several hundred dollars per annum as a means of heating their furnaces.

In a report now in preparation this question of gas-wells will receive a careful discussion.

ON THE IMPROVEMENT OF THE RIVERS OF KENTUCKY.

BY N. S. SHALER.

In response to the resolution of the Legislature of Kentucky, to the effect "that the State Geologist be requested to lay before this House, in the shape of a special report, such information touching the mineral and other resources of the regions bordering on the Kentucky river and its tributaries as he has acquired by his Survey, and the practicability and probable cost of reaching said resources by slack-water," which resolution was amended so as to read, in addition, "such additional information as he may have touching the mineral resources of the State, and also the most practicable mode of improving and making navigable the rivers of the State, and the probable cost thereof," I beg to submit the following report:

In submitting this report, I beg leave to make the following preliminary statement: In the month of August last I was requested by an honorable member of the present House to have a statement of the advantages which would arise from the extension of the slack-water navigation throughout the main stream and its tributaries. In accordance with the rule that has guided the work of the Survey, viz: to do everything to shape its researches so as to favor any effort towards the development of the resources of the Commonwealth, I took pains to extend the work of the parties operating in the eastern section of the State so as to get a good deal of information concerning the Kentucky river, and the upper waters of Green river. More has been done on these streams than any others, on account of this special demand; but the question of river improvement has been constantly before the minds of the officers of the Survey ever since its beginning, and now that special attention has been turned to our streams by the course of public inquiry, every effort will be made to gather all the information within reach of inquiry.

The expression, "and such additional information as he may have touching the resources of the State," leaves me a little in doubt as to the nature of the information sought. Four volumes of detailed and condensed reports on the mineral resources of the State have been reported to the Governor, and will be printed, as soon as possible, after the appropriation has been made as provided in the bill now before the Senate. We can only say that any synopsis of these reports, in a shape to be useful, would be scarcely less voluminous than the reports themselves. The general character of these reports will be seen in the preface of the first volume, already laid before the honorable members of the House and Senate, in an informal way. Copies of this circular, and all details of information, can be had of the Assistant in charge of the State Cabinet, Mr. John R. Procter.

In the following statement I have endeavored to give, in a general way, and without detail, the essential facts on which an opinion concerning the advantage of slack-water navigation can be based. In the matter of cost, as far as it is stated, I must say that I do not give the opinion as that of an expert in hydraulic engineering. Such works have always had a great interest for me, and I have seen and read much concerning their construction. Whenever possible, the opinions given are based upon the estimates of others. A detailed statement would require a very complete account of our rivers, so that the position of each lock could be carefully determined. In estimating for the work, I have estimated that it could be done, without profit to individuals, by the direct action of the State. I have merely estimated the cost of the labor, basing it on what seems to be trustworthy statements of the cost of similar works in this country and in Europe. If built by a system of contracts, or on the ordinarily wasteful methods of public improvements in other States, it would be easy to swell the costs to several times the figures given. I believe, however, from the high-toned way in which public trusts have always been administered in this State, that there will be no danger from this source.

In considering the future of the mineral resources of Kentucky, the following points must be kept in mind: 1st. That being, in the main, heavy products—coal, iron, fire-clay, building stone, salt, coal oils, and timber—transportation must be a large element in their market cost; and, therefore, that all that relates to the road to market, to its making, and to its cheapness after it is made, is very important 2d. That the Mississippi Valley, the region to which we must look for the principal

market for our productions, has several other areas, affording similar materials, which will come into competition with our own. 3d. That such is the relation of water transportation to all other modes of carriage, that, where it can be had, it will always be the cheapest means of bringing heavy goods of this character to their market. If we add to these considerations the fact that the Mississippi Valley has navigable water, with a shore line long enough to girdle the earth, we see the facts essential to the understanding of the problem.

A glance at the map of Kentucky, that has been prepared to show the best possible slack-water navigation of the State, will make it clear that we can easily develop our two thousand miles of coal and iron territory on slack-water navigation. This is at least thrice as much productive front as can be made accessible by water in any other State, and it lies more nearly in the centre of the area of consumption than that of any other State having anything like the same resources. Nature has done very much for us in laying out these water-ways, and in making them reasonably suited for the uses to which we must put them. It would have been impossible to have had a high, healthful country with a more serviceable set of streams. We cannot blame nature, but must criticise ourselves, that they are not the completed roads down which our products are finding their way to the fast-growing markets of the Mississippi Valley.

The mineral district of Kentucky consists of two areas—the western of about four thousand square miles, and the eastern of about ten thousand square miles—as will be seen from the detailed maps in the State Cabinet. Both these fields are extensively intersected by rivers, there being scarce any part of their areas that is more than twenty-five miles from navigable water, or that which could readily be made navigable.

The eastern and western fields differ a good deal as to the difficulty of this method of approach. The former has its coals much higher above the sea, the base or lowest part of the workable coal being probably not less than four hundred feet above the sea level, and its outcrop edge, on the western border of the field, averaging a hundred feet higher. In the western field the base of the coal extends below the level of the sea, and the greater part of the coal lies within four hundred feet of the sea level. A total lockage of seventy feet will be the most that will be needed to secure the fullest use of the water navigation adjacent to the western coal and iron field.

The eastern district is approached with more difficulty. From the Ohio to the beginning of the best coals of the Big Sandy it will require

but three, or at most four, locks, or a total lift of say forty feet. On Tygert creek it would require a total lift of about one hundred feet to make the stream fully available. On the Licking it would require about twenty dams, or a total lift of about two hundred feet, to carry the slack-water to the coal On the Kentucky, it will require eleven locks, in addition to those already built, to carry the navigatiton to the Three Forks.

By using the cheaper forms of slack-water, especially those forms where the lock is replaced by an inclined plane, up which the boats are dragged by oxen, and down which they slide when loaded as a launching ship slides on its ways, it will be possible to extend this form of navigation to smaller tributaries than are shown on the map of the proposed water lines of the State.

Considering the present project as limited to the improvement of the following streams: Big Sandy, Licking, Kentucky, Green, and Tradewater rivers, and that the lockage is completed, as far as the main streams are concerned, to do the best for their mineral resources, I estimate we would have something like the following statement:

Big Sandy (12) twelve to (20) twenty pools.

Licking (22) twenty-two to (30) thirty pools.

Kentucky (20) twenty to (30) thirty pools, less the five now existing.

Green (8) eight to (12) twelve pools, less the six now existing.

Tradewater (2) two to (4) four pools.

I omit the Cumberland, not yet having sufficient data concerning it.

The lesser number would give the basis of an extended industry in the development of our mineral wealth, for while we have very few miles of available coal on an uninterrupted navigation, we should have several hundred miles with the least of these numbers of pools. The greater number, ninety-six, should carry the slack-water system to essential completion on the main streams, leaving little to be done to serve the needs of centuries to come, save to deal with the lesser tributaries.

The cost of this improvement is hard to determine, even approximately, so much depends on the form of the dams, size of locks, &c. For the Big Sandy, I recommend the French system of lowering locks, now in use on the Seine. This will prevent the filling of the pools with sand. Such dams are far more costly than the ordinary form.

On our other rivers the ordinary dams will serve very well, and can be built very cheaply. I am inclined to think that, considering the accessibility of stone and timber, that, taking these dams altogether, an average

of sixty thousand days of labor should suffice for their construction, in a substantial way, on the dimensions of the present locks and dams on the Kentucky river, cut of durable stone, with the exception that the dams would be shorter on the upper waters, and the locks might have to be smaller on the Tradewater river, and on the upper parts of the other streams. A greater economy could be secured by taking a cheaper stone for the masonry than has been used hitherto; and the lock gates and the dams should be better protected against accident.

I am informed that the cost of convict labor, including all expenses of subsistence, guarding, clothing, &c., need not exceed fifty cents per diem. I have had it estimated as low as thirty cents. On this point I have no opinion. Putting the labor at fifty cents per diem, the locks and dams would probably cost about thirty thousand dollars apiece. Incidentals might swell this figure a good deal. The first locks built would generally be the most costly, as the dams would be larger, and good building stone and timber harder to get. If these figures are correct, we see that, with convict labor, the rivers of the State could be made to serve as transportation routes, in a most efficient manner, for from two to three million of dollars, besides the cost of the materials used in construction. This would probably not aggregate more than one million, but I do not venture upon an estimate. This cost would be distributed over a long series of years. On the supposition that each dam costs sixty thousand days' labor—and I believe this is an ample estimate—a force of five hundred men would require about thirty years to build the number of dams required. The annual charge on the Treasury should, it seems to me, fall within one hundred thousand dollars. It seems probable that within five years, at the present rate of growth of the State, at least eight hundred men can be spared for this work without breaking up the Penitentiary system at Frankfort. This would give a measure of completeness to our river navigation in less than twenty years.

The advantages of river navigation to any district are exceedingly great, even where there is no mineral wealth to develop. Let us consider, for instance, the Licking, which runs further through a non-mineral country than any other river in the State. For forty miles a railway runs along its left bank, so its claim for navigation facilities is less than any other stream in the State; but if we allow only five dollars per acre increase in the value of the agricultural land within five miles on either side of the river, and two dollars for the next belt of five miles still further

back, we see that the proposed improvement would add six million of dollars to the taxable value of the valley, allowing nothing for villages and manufactories that would be brought into existence by cheap coal, iron, and timber on permanent navigation.

So we see that the present rate of State taxes on this district, the value added to the lands would pay the interest on the cost of the improvement, without considering the added value of mineral lands, which would represent a far greater increase. It is not beyond reason to estimate each acre of coal and iron, made accessible by water, as worth, within fifty years, one hundred dollars (besides its agricultural value), and that all the coal and iron, within say three miles, is so made accessible. Now, if we get one hundred miles of navigation in a coal and iron district, we add nearly four million to the estimate. So, from the tax-paying point of view, and allowing nothing for the growth of population in villages and manufactories, we see that this may be a very good investment for the State. But the marketing of over one hundred acres of our coal may bring on the average something like three million dollars into the State, so that in the industries set in motion we will find the greatest advantage of these improvements to the State.

The resolution calls for a statement as to the best means for accomplishing the improvement of our rivers. A complete discussion of this question would require an exhaustive treatise on the most complicated part of hydraulic engineering, and should come from a special engineer. I will give a brief resume as to the possible means, as they are used on the rivers of France and Germany, countries where the greatest amount of care has been given to rivers which in size and character much resemble our own. I leave out of the list the system of wing dams, which, though useful where there is always a large body of water, do not suit the needs of our rivers, which so often fall to a very low stage of water. Thus limited, the following are the important systems of slack-water we find there:

1st. The ordinary system of locks and dams, such as are already in use in our own State. This ancient model needs no description. The locks are of the ordinary canal fashion, and the dams are wooden structures. In Europe, the dams are more often made altogether in large part of stone than here.

2d. The system, or rather several different systems, of movable dams, so arranged that in flood times boats can pass over the dam, which is lowered by sections into a masonry bed on the bottom of the river. This plan is used on streams as large as the Kentucky or larger. It is

a costly system, inasmuch as the whole support of the dam comes from a series of iron frames, hinged to a massive stone floor laid across the river. Its advantages are considerable, however, inasmuch as it allows boats and rafts to pass down stream, during the flood times, without going through the locks, and what is of even more importance, it avoids the danger of the filling up of the pools with sand and mud. Dams constructed on this principle would probably add as much as one third, possibly more, to the cost of work done by contract, and probably far more when done by convict labor than the common dams, owing to the amount of metal and the skilled labor required. For the Big Sandy this sort of dam would be very desirable, owing to the large amount of floating sand, and the difficulty of finding secure foundations for the ends of the dams. The merits and cost of these movable dams should be carefully considered. I shall be able, with a few months' notice, to furnish detailed information concerning their construction, whenever it is required.

3d. Another system of very different construction exists in Germany, and is also used at some points in other countries. In it there is no lock, but the boat is taken, when empty or with light loads, up an inclined plane, which extends from the pool below to the top of the dam above. The power can be either that of oxen or some form of engine worked by water or steam. Boats can be launched down this incline with the greatest ease. The advantages of this system are its cheapness, the cost for each foot of lift secured being only about one half the cost where it is gained by the ordinary method with locks, and the small amount of water required, a few cubic feet only being used in the passage of each boat. The disadvantages are the limitations in the size of boats, it being difficult to manage boats of over one hundred and fifty tons burden, and the cost of the power used to haul the boats up the incline. It is generally done by oxen, so that the costs of attendance are not very great, though greater than in the case of ordinary locks. It would be quite possible to do this work of hoisting boats by means of water-power derived from the dam itself.

4th. The last system I shall notice may be called that of temporary floods. A dam, or series of dams, on the head waters of a river is filled by the flow of the stream, all the water, it may be for days, being held back in the reservoir. At the appointed time the dam is lowered, and the flood rushes down, carrying with it the rafts and boats that await its coming. As often as the water allows, but at stated times, this flood is repeated. Its time of arrival at each point is accurately known, so all

the preparations for the movement of boats can be made. The advantages of this method are found in its evident cheapness, but the disadvantages are very great. The return of boats up the stream is very difficult, and, on our rivers, would be practically impossible. Moreover, the flood tends to outrun the boats or rafts, and gives much more trouble from the consequent delays than would be readily imagined. After a very long trial, the French Government has abandoned, or is abandoning, the system on most of its rivers. I cannot, therefore, recommend the expenditure of much money upon it. I would, however, advise that, in making any system of dams on the Kentucky or our other rivers, the question be considered whether it would not be well to have one movable dam well up the stream to arrest the flow of water for several hours each day, so as to give a better opportunity for the work of construction, while the intervening floods of a few feet would aid in transporting the stone and timber when it had to be brought from a distance. This would also serve as a means of testing the value of this system of regular floods in our rivers.

I venture to recommend the consideration of the question of trying all the above named systems of improvement, as the circumstances of the several rivers admit. A single dam on the movable plan could be easily tried in the Big Sandy. The flooding system might be tried in another stream, in the manner just suggested; and in a stream like Tygart's creek, it would perhaps be worth while to see whether the system of lifts, without locks, could not be made effective. The possibility of using timber locks, especially in streams where good building stone cannot be obtained, is well worthy of consideration. With a proper ballasting of rip-rap stone, and some cheap process of giving security against decay to the timber that is beyond the line of permanent moisture, there is no evident reason why these locks should not answer as well as the floating docks used at marine stations, which often outlast generations.

I beg leave to say, in conclusion, that the Geological Survey is prepared, within a year, to make a detailed study of the whole question of slack-water navigation, provided the means therefor are put into its hands. Two of the officers of the Survey have given much study to this question, and we can obtain the aid of the most eminent authorities in this country and Europe in the discussion of the problem. I would suggest that an appropriation of three thousand dollars be made for collecting information, and in preparing a report for publication. This need not delay the operations of construction. Work on locks can be

begun, and these structures carried to completion, before it will be necessary to decide on the matter of movable or fixed dams, or the precise mode of construction of any model that is determined on. So while it seems to me of great importance that there should be a carefully planned study of the most effective modern appliances for accomplishing the best results with the least labor, it does not appear necessary to postpone the active work of building.

I very much regret that this call for information does not admit of the delay which would be necessary in order to answer, in more than generalities, the important questions which have been put to me. If it is the pleasure of the General Assembly to charge me with the duty, and provide me with the means of giving detailed information, I can have it ready within a year.

ON THE IMPORTANCE OF IMPROVEMENT IN THE NAVIGATION OF THE KENTUCKY RIVER TO THE MINING AND MANUFACTURING INTERESTS OF KENTUCKY.

BY N. S. SHALER AND JOHN R. PROCTER.

PART I.

A GENERAL STATEMENT.

In the Biennial Report of the Director of the Survey for 1878, the general matter of the navigation of our Kentucky streams in relation to the mineral resources of the State, their use within its borders and their exportation, is considered at length. In this report the intention is to discuss the special questions of that nature, as far as they pertain to the Kentucky river. A glance at the general map of the State will show that the eastern coal and iron district of Kentucky, which includes over two thirds of its mineral area, is practically deprived of all means of transportation. By the widening of their beds, consequent on the destruction of timber along their banks and over their drainage basins, the Big Sandy, the Licking, the Kentucky, and the Cumberland, which penetrate its boundaries, and have afforded the way for most of the transportation that has been had from this area, have become less and less available as outlets for its coal, iron, and other products. Two railways have touched its borders, and a third has penetrated over thirty miles into its field; but the map will show better than words how little of the region has been developed in this way. Imperfect as are the results of these railway routes, they seem to show how much can be done for this region by transportation facilities. The counties of Greenup, Carter, and Boyd have been lifted by them out of their poverty and set on the road to great wealth. The effect of these new roads has only begun to be manifested; but if we could only carry the development of the whole region of Eastern Kentucky to the same relative point of advance, the addition to our taxable wealth would be counted by hundreds of millions, and the population of the State would gain an addition of at least a million of souls.

In considering the future of our mineral industries, we must not lose sight of the fact that we are placed in the great river valley of the

Ohio, where there are many sources of supply whence may come the materials which we can furnish to the arts of our time. All the States bordering the waters of the Ohio system, excepting New York and Mississippi, may compete in the production of iron and coal of much the same qualities as those found within our own borders. We are convinced that in the character of these ores, and in the circumstances of position, our Commonwealth has some advantages over all its competitors; but to assure these advantages we must make a total change in our system. We must abandon the policy of neglect hitherto pursued in our dealing with questions of transportation, and set to work making ways to our wealth. Nature has done as much for us in the roads to our mines, as she has in laying the wealth beneath the ground. The work is more than half done, and the capital and energy required to bring it to completion is but a trifle in comparison with the advantages which would come from the possession of these ways.

In considering the capacities of Kentucky for the production of wealth, too much importance cannot be attached to its natural waterways. The great market for its heavy products will always be along the waters of the Mississippi river system; and it is our peculiar fortune that there are half a dozen rivers in the State which reach far up into the mineral districts, and only require the measure of improvement that can be given them at small cost to become the most perfect mineral roads known to art. It is a fact beyond contesting that water transportation is, and from its nature must always remain, the cheapest form of carriage for heavy products. Railways will serve for purposes of local supply of coal, iron, and timber within our borders, and along the future routes that lead towards the sea; but in the struggle for the markets of the Mississippi Valley, the great economic battle in which the prize is imperial wealth, success will be won by the use of the cheapest transportation. A glance at the maps used by the Survey to indicate the river basins, and the possible slack-water navigation of the State within the mineral districts, will make it plain that the Kentucky river penetrates a greater distance into the eastern coal and iron district than any other stream within the control of this Commonwealth. Its waters susceptible of improvement will give, when they are made navigable, a coal and iron frontage of not far from eight hundred miles. This region will be more accessible to the Ohio river, as far as the barrier of lockage is concerned, than Central New York is to its metropolis by the Erie Canal. It will discharge its products within ready reach of the two great markets of the Ohio, Louisville and Cincinnati, and on its banks,

within one hundred miles of the outlet of the Kentucky, it will command the markets of nearly a million of people. On the lower Ohio and Mississippi it will have great advantages over the Pittsburg products, in that the treacherous navigation of the upper Ohio has been escaped, and the water is more uniformly of a navigable stage throughout the year.

While considering the general relation of this stream to the State, we must not lose sight of the fact that it is the only stream that can be made of great use to our principal city. At Cincinnati there is not only a great market, but its industries and those of the neighboring cities in Kentucky have demanded three bridges over the stream, two of which are most dangerous to the passage of boats unprovided with steam power, and even to the fleets of flatboats in tow of a tug. Two more pier bridges are sure to be built within ten years, and then the navigation will become so hazardous as to put a very heavy tax on the industry of Louisville, as far as it is determined by the products of the upper Ohio. It is the opinion of experts that these bridges will make a ruinous difference in the price of coal at Louisville. While we are convinced that the western mineral district of Kentucky is in itself enough to give manufacturing greatness to Louisville, if its resources are developed with energy, it must be said that water transportation does not take its products in that direction. The only chance of keeping a control of the wealth of Eastern Kentucky for our principal city, and of securing to it a fair race in the struggle for cheap power, is through the improvement of the Kentucky river. There can be no question that the city of Louisville would profit largely from the trade of this district. We believe that coals that will compare very favorably with those of the Pittsburg coal district, can be put at her wharves at a much lower price from the Kentucky than they can be furnished from the upper Ohio.

The iron from the Sub-carboniferous ores has a name and place in the markets that has never been held by any other. The region whence it may be obtained by this navigation is sufficiently extensive to furnish a supply for dozens of furnaces for a century to come. The possibility of supplying cheap charcoal and ore to those furnaces will be dependent on water navigation. With this in working order, there would be hundreds of miles of water front from which the supply could be drawn.

The question arises as to how far the resources of this stream will enable its industries to prevail in the struggle with those from other States. In the first place, as regards distance from transportation, it is

to be noticed that from Louisville or Cincinnati the distance to the centre of the mineral district of Eastern Kentucky is not far from two hundred and seventy-five miles by this water route; while to the centre of the present source of coal supply at Pittsburg is about twice that distance. It is true that the Kentucky river would have the disadvantage of over a dozen locks to be passed in order to get access to the mines; but this, in my opinion, would be quite balanced by the greater certainty of navigation and the freedom from risks of wrecking. If the State controls the navigation, the tolls would be so small as not to have much value in measuring the expense. The closure from ice would probably not average more than a month each year, and the navigation to Louisville and Cincinnati for coal-boats of light draft would rarely be interrupted for more than a month in the year by shallow water. Ten months of assured navigation, in place of about five months of accidental rushes for a market, would clearly give this region a great advantage in the production of coal and iron for the Louisville and Cincinnati markets.

As regards the character of the beds of coal, iron, salt, and other materials, by far the greatest part of the facts are doubtless to be learned from the more complete exploration of the country. There is enough known, however, to make it clear that both in variety of products, and in the facilities for obtaining them, this region can successfully compete with any other within the drainage basin of the Ohio river. The appended special descriptions of the mineral resources of the upper Kentucky will give a part of the details already accumulated by the incomplete work of the Survey. It will be seen from those records that there is a mineral field of at least three thousand square miles which can be made accessible by this form of improvement. Of this, about two thousand five hundred will furnish coals of varied qualities. A large part of this coal is about as good as Pittsburg for house and steam uses. The main Sub-conglomerate coal, the equivalent of the Pine Hill coal at Livingston, is a superior gas coal, giving, as found at Pine Hill, within ten per cent. of the amount of gas found in the best Pittsburg coal, according to the determination of the superintendent of the gas-works at Crab Orchard Springs. Though the lot of coal from which the determination was made was not as well selected as it might have been, it is quite probable, from the analyses and from the experiments made with these Sub-conglomerate coals in Tennessee, that some of them will serve for the smelting of iron ores in their raw or uncoked state. By this means, or by coking, there can be no doubt that we will

find an abundance of cheap stone-coal fuel for furnaces in this district. The cannel coal that can be furnished by this district is practically inexhaustible, and of excellent quality. Besides its great value for home use, there is a large and growing demand for this material to enrich coal-gas. The considerably higher price of this coal enables it to be carried over a wider field, and the States of Ohio, Indiana, and Illinois would, throughout their extent will be within the probable range of these coals via the Kentucky river.

Associated with these coals we find an extensive series of fire-clays, some of them likely to prove of considerable value, though their precise importance is not easy to determine at the present time. The conjunction of good clays, cheap fuel, and water transportation, ought to open the whole Mississippi river system to these sources of production. The demand for the various forms of bricks, tiles, and retorts made from fire-clay, is already to be counted in this country by the millions of dollars annually, and each advance in our population or industries will greatly widen the market.*

The iron ores of this district have been but little developed, and such ores are generally so far hidden beneath the surface that much and continued research is necessary in order to show their real character and extent. Even in well-known iron districts, where workings have been carried on for half a century or more, it is not uncommon to fall upon new and valuable beds that had been previously overlooked. In an almost unbroken wilderness, where the iron industry has been limited to a single furnace, it is not to be expected that we shall know more than a small part of its real resources in the way of iron ores. Enough is known, however, to make it quite certain that there exists here the basis of a very extensive iron-making industry. The ores which are found on the top of the Sub-carboniferous limestone, and which have furnished all the ore used in the famous Red River Furnace, has been found to cover a large area both on the north and south slopes of the Kentucky river. All the Sub-carboniferous limestone which has its top above the level of the drainage may reasonably be expected to contain the ore; and wherever it has been seen by the parties of the Survey, it has been of workable thickness, and of the same excellent quality that has given value to the beds on Red river. It is probably much within the truth to estimate the area of this ore above drainage, on either side of the river, at two hundred square miles—of which relatively a large amount would

* See forthcoming report in the 6th volume of the series of economic reports on pottery clays and their products.

be accessible by benching, on account of the much intersected character of the surface.

The valuable deposits of the Preston Banks are within a short range of transportation of the Kentucky river. Any one of the several projected railways from Mount Sterling will be apt to bring these ores within reach of the Kentucky river. When this is the case, there will be a chance to mingle the ore from these beds with the Sub carboniferous limestone ore of the Kentucky river. We as yet know nothing of the outcrops above the last named ore, and they are probably less rich than in the basin of the little Sandy or in Western Kentucky. But, as before remarked, the limestone ore is of itself extensive enough to become the basis of a great industry.

The salt belt of Eastern Kentucky includes all the country east of the line where the black shale of the Devonian series falls below the drainage of the country. Practically, it may be said that all the land which has coal-beds near the drainage level comes within the salt belt. At present salt is made at a profit at only two points—near Manchester, on Goose creek, a branch of the South Fork, and at mouth of Troublesome creek on the North Fork. It seems pretty certain, however, that salt water can be found over nearly all the eastern coal field. It will naturally be found of varied strength at different points; but it is my conviction that the observed variety of strength is rather to be attributed to the imperfect tubing of the wells, which does not effectually exclude the water of higher levels, than that which carries the salt. We have little doubt that the use of proper precautions would give a good supply of salt water at almost any point within this district.

A considerable value is to be attached to the building stones that would be made desirable by water transportation on the Kentucky. Along the Kentucky cliffs there are several points where Kentucky marble, a dolomitic limestone of excellent and varied character, can be had under circumstances very favorable for quarrying. This well known stone, one variety of which is seen in the Clay monument at Lexington, is admirably fitted to stand the rigors of our climate. It is easily worked, and of great strength.

Further up, near the mouth of Red river, we come upon the stone known as the Buena Vista sandstone, which has been for many years very extensively quarried along the Ohio river in the neighborhood of Lewis county. It is now shipped to Chicago, New York, and even to

Boston. Beds of this stone can be quarried to great advantage at many points on the main stream and its tributaries, and we may reasonably expect a good market for it in the Ohio river cities. The excellent stone used in the court-house at Paris, Bourbon county, can doubtless also be found at several points near the Kentucky river, and will serve to add to the variety of building materials.

The timber supply is extensive, and remarkable for the great variety of species which seem to find here their best conditions. There is a considerable quantity of yellow pine, of a size fitting it for use in the arts, and some white pine of rather inferior quality; some hemlock, and a good deal of cedar timber may be had in the district. The main export will be of the non-evergreen species of our forest trees—oaks, hickories, poplars, &c. The drainage of the Kentucky above Frankfort contains probably not far from three thousand square miles of forest land, which is continually yielding successive crops of our most valuable woods. The investigations of the Survey in the Little Sandy district show conclusively that the soil of Eastern Kentucky readily reproduces its forest vegetation of the same kind as that which has been cut away; so that there is no doubt that the supply of timber from the lands unfit for agriculture may be continued for an indefinite time.

Some exportation of these woods to Europe has already begun. Last year about five hundred logs of walnut were shipped from Frankfort by car to New York, and thence to Germany; and we are informed by J. G. Dudley & Bro. that there will be several times as much sent this year by the same road. Although this method of shipment entails a far greater cost than would be incurred in exporting by the water route to New Orleans, it will doubtless be found profitable at the present rate of prices, which will pretty certainly not be lessened in the future. The whole of the upper part of this valley will be found peculiarly fitted for the growth of this species of timber, without any planting whatever, and with only reasonable care to those parts of our forests in this valley which do not occupy land fit for agriculture, it can readily yield ten thousand walnut trees to the woodman's axe each year for centuries to come. After taking out the land fit for agriculture, there will remain in this valley not far from ten thousand square miles which should be devoted to timber-growing, in order to furnish timber for the mines and for export.

The agricultural value of the land to the eastward of the Bluegrass belt is greatly underrated. The popular prejudice has stamped it as mountainous and uncultivatable. It is true that a great deal of it is too

rugged for profitable culture; but there is a great deal of tillable land exceedingly well suited for many crops. Chemical analysis, as well as the surer test of actual experiment, goes to show that a very large part of it is admirably well fitted for the growth of tobacco of a very fine quality. There is no doubt that, when transportation is furnished, this will become an important article of export from this section.

While the methods of construction of locks and dams is a matter that does not come within the province of the Survey, I venture to call the attention of those interested therein to the variety of means now employed in other countries for the more effective improvement of rivers. Two great evils have to be met in all schemes for canalizing rivers. The first is the difficulty that comes from the fact that, even in times of flood, the rafts and boats cannot make use of the chance of going freely and without delay to their market during floods, but must take their turn slowly at the locks. This has been successfully overcome in France by a system of movable dams, so arranged as to lower down on to the river bed, leaving the way unobstructed in times of flood, being raised to their place after the rush of water has gone by. This system is now used in the Seine, and has stood the test of several years of operation. This system offers some great advantages. The dams are not likely to be taken away by floods, and the pools never fill with sand and mud.

The other great difficulty in extending lock navigation has been, that in small streams there is sometimes a want of sufficient water to serve for lockage purposes. This has been obviated in Austria by use of inclined planes in place of locks. Those inclined ways lead from the pool below to the top of the dam. A small amount of water is allowed to trickle over them, so as to make the friction less, and then the boat is dragged up by oxen. The slope being only about two feet in one hundred, boats on a cradle, or even slipping on the wet inclined way, can be taken up pretty easily. In descending, the boats slide down the incline as a ship is launched.

Despite my conviction of the special advantages of these improvements on the old method of slack-water navigation, I think it may, on the whole, be desirable to continue the improvement of the river, at least for the present and for the main river, on the plan already in use on its lower waters. The other and more complicated systems of dams have the disadvantage of being, in some cases, more costly, and in all cases of not having been submitted to the test of the conditions prevailing in our American rivers.

One lesson at least we can learn from other lands: it is the great value of slack water navigation even in regions where railways run side by side with the streams. The extraordinary prosperity of France is in good part to be attributed to the admirable system of internal water navigation which has been most carefully perfected at the cost of the State. I am fully convinced that the Commonwealth of Kentucky will find no other way of gaining a hold on the great industries of this country half so effective as through the improvement of her water transportation.

The following synopsis gives the results of the Surveys of the river, and the work that has already been done in the way of exploring the mineral resources of the region adjacent to the upper waters of the Kentucky.

Many years ago the Commonwealth made provision for a Survey of an extension of the proposed slack-water navigation of the Kentucky river to Cumberland Gap, by way of the South Fork of that river and Goose creek to the head waters of Richland creek, a tributary of the Cumberland, and thence by canal to the main stream of the Cumberland at the point where Pineville now stands. Then it was proposed to resume the slack-water navigation, and continue it by way of Yellow creek to Cumberland Gap. Then by a tunnel of less than one mile, through rocks that are easily penetrated, it was proposed to pass into the valley of Eastern Tennessee. A great spring at the Gap and the head waters of Yellow creek promised water enough for lockage to lead the navigation into the valley of the Powell river, whence, by easy gradents, it would be possible to carry it through the whole of the great river system of the upper Tennessee. By way of the Hiawassee river, by a short canal, it would be possible to extend this form of navigation through to the Savannah river, and thence to the sea.

After a careful study of the route from the Kentucky river to Cumberland Gap, it seems to us evident that the project is entirely feasible, and likely to have a very great importance in the development of the mineral resources of this State as well as of East Tennessee; and furthermore, that the cost of this water-way is likely to be exceedingly small when compared with the practical results likely to be obtained from its workings.

Considering area, accessibility, neighborhood to suitable coal and other advantages, the "dye-stone" ore of the Cumberland Mountain district is probably the lowest field of ore in the Mississippi Valley, and

I believe will, when transportation is furnished, produce cheaper iron than any other ore in America. The coals to work this ore must, to a great extent, come from Kentucky. The ores from the coal series of rocks within our State would furnish a valuable basis for admixture with the "dye-stone" ore. If we could have a system of transportation as cheap as water-ways furnish from the Cumberland Mountain towards the Ohio river, it would give us a close hold on this great mineral district. Owing to the relation of the materials, the ores will always seek the coal, the limestone, and the facilities furnished by water-powers. The district of the upper Cumberland and the Kentucky river would, we believe, become the seats of production of the iron from the "dye-stone" ore, rather than the region of East Tennessee.

As soon as this water navigation is carried to Cumberland Ford, it will be found possible, at small expense, to extend the slack-water up the upper Cumberland to Poor and Clear Forks, and to some thirty miles or more beyond Harlan Court House. This would render a great valley, rich in coal and timber, quite accessible. But for some such system, it is likely to remain for a great time without any transportation facilities.

With this canal system carried to Cumberland Gap, its extension via the Powell, Tennessee, Hiawassee, and Savannah to the sea, would be assured in time. We believe this to be one of the few practicable water-ways from the central region of the Mississippi to the sea. It would have the advantage over present Northern water routes of at least four months more navigation in the year. There can be no doubt that the next century may see, at its very beginning, the Ohio valley, with its unequaled cheap fuel, its store of iron ores and of manufacturing timber, its wealth of food, the centre of activity of those industries that have given Great Britain its manufacturing greatness. It depends on our immediate action whether this production shall find its centre in Kentucky, or whether she shall get the least share of it. The way to determine this matter to our satisfaction is to set about the improvement of all those natural channels which can secure the cheapest transportation. When that is done the rest will follow without effort.

Part II.

A careful observer, after an extended tour of observation through our State, writes: "There is no reason why Kentucky should not already have recived a mighty current of immigration, excepting the negligence of her people with regard to their own interests." To convince our-

selves of the truth of this, let us make comparison of our development with States of like natural advantages, that have profited by these advantages, by affording transportation facilities for the development of their resources. For this reason take Pennsylvania and Ohio, those States being about the size of Kentucky, with near the same area of coal-fields, the advantages being in favor of the latter, as follows:

Ohio having	10,000	square miles of coal fields.
Pennsylvania having	12,630	" "
Kentucky having	12,771	" "

In iron ores we believe the present Geological Survey of the State will develop the fact that our State has the advantage over either of those States. Hard-wood timber, suitable for manufacturing purposes, is more abundant, and in timber suitable for charcoal, convenient to iron ores, Kentucky has a decided advantage. Our undeveloped water-power exceeds the water-power of those States. Yet with these natural advantages, what have we to show in actual production to compare with them?

The value of the products of mining industries in 1870 was:

In Kentucky	$509,245
In Ohio	7,751,544
In Pennsylvania	76,208,390

Our mineral districts are capable of supporting a denser population, yet there are less than five inhabitants to the square mile in the mining districts of Kentucky, while in Ohio there are from forty to seventy-five, and in Pennsylvania from forty-five to one hundred and twenty-five.

The distribution of wealth in the mining districts of the three States in 1870 was:

In Kentucky less than	$300	per capita.
In Ohio from	750 to $1,250	"
In Pennsylvania from	1,250 to 2,000	"

Notwithstanding the superior quality and quantity of our hard-wood timber, the value of agricultural implements manufactured in 1870 was:

In Kentucky	$1,384,917
In Pennsylvania	3,652,295
In Ohio	11,907,366

We know from personal observation that this Commonwealth greatly surpasses Ohio in timber suitable for hubs, spokes, felloes, &c.; yet Kentucky manufactured $38,232 worth, and Ohio manufactured $1,712,808 worth.

Most of the raw cotton passes the entire length of our State on the way to Pennsylvania, yet the value of cotton goods manufactured in the two States was, in 1870:

In Kentucky	$498,960
In Pennsylvania	17,490,080

The water-power of Kentucky is greater, yet the following table is instructive:

	No. of wheels.	Horse power.
Kentucky	459	7,640
Ohio	2,157	44,746
Pennsylvania	7,603	141,982

Notwithstanding the extent of the Kentucky coal fields, and the facilities which a judicious expenditure would afford for getting the coal to market, and use it in profitable home manufacturing industries, in 1872

Kentucky mined	340,000 tons.
Ohio mined	3,000,000 "
Pennsylvania mined	29,442,000 "

The reason for these great differences is, that Kentucky has practically ignored the existence of her great natural advantages and mineral wealth, and has, as it were, permitted a Chinese wall to hedge in the richest portion of her domain, whilst Ohio and Pennsylvania, by affording canal and railroad facilities to their mines and manufactories, have made rapid advancement in material wealth.

In addition to the railroads, Ohio has built two canals connecting the Ohio river with the lakes One of these showed a clearance of 2,213 boats in 1870, a clearance of 4,001 boats in 1871, and a large increase every year since.

Pennsylvania has built 869 miles of canal, at a total cost of $36,816,728. These canals have not only aided in the development of that State, and added countless millions to its wealth, but they are now not only paying good dividends on the original cost, but on largely watered stock. The Delaware and Hudson, for instance, cost $6,843,910, and is paying 7 per cent. on $20,000,000 of stock.

As positive proof of what we can reasonably expect from a perfect system of slack-water navigation in the development of our mining interest, examine the rapid increase and development of the country adjacent to some of those canals.

The first year the Lehigh Canal was opened it carried 365 tons of coal, which was the opening up of that coal region. In 1872 that canal carried near one million tons of coal, and the Lehigh region mined over three millions of tons.

The Schuylkill coal region was opened up by the Schuylkill Canal, and the Delaware and Hudson Canal, the first year producing only 1,480 tons. In 1872 that region produced 6,469,942 tons of coal.

It can be proved that where Pennsylvania has 869 miles of expensive canals, only from 40 feet to 100 feet wide, on which steam as a propelling power cannot be used, costing much each year to keep the artificial embankments in repair, closed several months every year by ice (the Delaware and Hudson being closed, on an average, from November 29 to April 6), that Kentucky can have over one thousand miles of cheap slack-water navigation easily kept in repair, of an average width five times greater than the Pennsylvania canals, on which good size steamboats can run at all seasons, rarely affected by ice, and affording by their water-power alone a benefit far exceeding the original cost.

The whole estimated cost of slack-water navigation, as completed and projected under direction of the Board of Internal Improvement in 1839, based upon the actual cost of work then completed and contracts made, was $5,837,000, and that expenditure would have given the State 816 miles of slack-water navigation, opening up to commerce all portions of the State. This would be at the rate of $7,150 per mile, and was an overestimate, as the actual cost of slack-water improvements on Green river was $859,126, giving 180 miles slack-water to Bowling Green, and including the slack-water above Barren river, and on the tributary streams, 268 miles of navigation, or $3,206 per mile; and the contract made on Kentucky river at a recent date was $6,209 per mile.

As the improvement of the Kentucky river will open up the largest undeveloped district, besides affording facilities for the interchange of products between twenty-four counties of the Commonwealth, I have been at some pains to collect facts respecting the resources of the country adjacent to it, and the means by which it may be made navigable. From the imperfect records now extant of the old surveys made under the direction of the Board of Internal Improvement, and the recent researches of the State Geological Survey, I am enabled to collect the following facts:

From the mouth of the Kentucky river to the Three Forks the distance is 257½ miles, with a total ascent of 212 feet. There are completed five locks, affording navigation to the first 96 miles, leaving 161½ miles to be completed. From the Three Forks to mouth of Troublesome creek it is 55 miles, with a raise of 39 feet. The cost of slack-water navigation from the head of navigation at Lock No. 5 to mouth of Troublesome creek would be $1,275,000, or about $6,000 per mile. This would be at the rate of $6,209 per mile to Three Forks, and $5,000 per mile from there to mouth of Troublesome creek. Contracts were made

at this rate in 1870, and we are informed by the contractors that it could be done for less now.

The following table will show the feasibility of this plan, and the advantages of this river:

	Length, miles.	Lockage, feet.	Width of channel, feet.	Total cost.	Cost per mile.
Kentucky river to mouth of Troublesome creek	312½	296	250	*$1,275,000	$5,902
Erie Canal	350	689	70	43,639,324	124,683
Delaware and Hudson Canal	108	1,073	48	6,339,210	60,200
Lehigh Canal	46	361	60	4,455,000	51,208
Ohio Canal	308	1,207	40	3,225,684	10,473

*This does not include the work already done on the lower part of the river.

The improvement of the Kentucky river will cost less, the lockage is less, and the width is greatest. Some of these canals are troubled for supply of water at the summit in summer. The Kentucky river at lowest water in summer runs 20,000 cubic feet of water per minute below the Forks, and 8,000 cubic feet per minute above the Forks, affording not only ample supply for navigation, but a large water-power surplus for manufacturing purposes.

From the mouth of South Fork to the salt-works above Manchester, it is 68½ miles, with a raise of 206½ feet. The estimated cost of slack-water improvement to the salt-works—giving a channel from 150 to 200 feet wide—is $411,000. At the lowest stage there is only 393 cubic feet per minute of water in South Fork, hardly enough for slack-water navigation; but a cheap system of reservoirs could be constructed, so that an ample supply could be assured at all seasons. This brings us to another important subject: the feasibility and utility of a canal connecting the Cumberland and Kentucky rivers.

We have not space to go into the details of the survey, but it was demonstrated that it could be easily and cheaply accomplished.

The Cumberland river at Barbourville is 121 8-10 feet higher than the waters of the Kentucky river at the Goose Creek salt-works. The summit divide between the head of Richland creek (emptying at Barbourville) and Collins' Fork of Goose creek, is 78 feet higher than low water at Barbourville, and less than a mile through. A dam 25 feet at Barbourville, and a cut at the summit less than a mile long, 53 feet deep in the centre and lessening at the ends, will let the waters of the Cumberland flow through, giving a channel six feet deep. This cut would be

through shale, with no fixed rock. The amount of water taken from the Cumberland would be inconsiderable, as it would only flow through when boats were passing the locks, and the supply taken for the canal would be from the reserve held back by the dam at Barbourville, and would not affect the river below that point. This dam at Barbourville would afford slack-water to Pineville, and from there, by way of Yellow creek, slack-water could be carried to the foot of the Cumberland Mountains, at Cumberland Gap. Mr. W. B. Page, of the United States Coast Survey, estimates the valley of Yellow creek to be 1,100 feet above the sea, and as the mouth of the Kentucky river, at the Ohio, is 416 feet above the sea, the entire lockage from the mouth to Cumberland Gap would be 684 feet, or 5 feet less than the lockage on the Erie Canal.

The length of canal from Barbourville to the Goose Creek salt-works would be 21½ miles.

At Cumberland Gap a tunnel about 1,400 yards long, and a canal six miles down the Gap creek valley to Powell's river, will connect the entire river system of Tennessee, and give thence a direct outlet through Kentucky for their products.

This would also connect with the river and canal improvement, proposed by the United States Government, connecting the Tennessee river with the streams flowing into the Atlantic Ocean.

This measure we believe well worthy the attention of the State, as it is capable of producing more important results to the States of the Ohio Valley, as well as to the cotton States west of the Mississippi, than any other plan of internal improvement within our knowledge.

We have, as briefly as possible, spoken of the capabilities of this river for cheap and reliable navigation at all seasons. A hasty review of some of the resources of the country that would be developed by this system of improvement, will, I hope, awaken the people of this State to its importance.

In the region drained by the upper Cumberland and Kentucky there is more black walnut timber than any other region of like area with which we are acquainted. White oak and poplar, of large size and superior quality, is very abundant. The difficulty of running rafts over the Falls of the Cumberland and the Smith's Shoals has prevented, in a great measure, the running of timber from the upper Cumberland, so that the forests of that country have been scarcely touched. On Red river there is an extensive region covered with a fine growth of white pine, being, so far as I am aware, the only white pine, of any extent, in the Ohio Valley, west of Pennsylvania.

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It has been said that a country which exports the raw material ends by exporting men, and that prosperity can never be enduring unless based upon productions. Even now, the admirable hard-wood timbers are being bought up and shipped to other States, where they are manufactured at large profit, while the citizens of our own State receive but a tithe of their value.

The proposed system of river improvement would set the now idle water-powers of that section at work, so that this timber could be profitably manufactured there, and the manufactured articles shipped abroad.

Central Kentucky is now chiefly supplied with coal brought from 50 to 85 miles down the Monongahela river, through locks and dams; then 540 miles down the Ohio river to the mouth of the Kentucky; thence through four locks up to Frankfort, where it is distributed over the State.

One hundred and ninety-one miles above Frankfort, on the Kentucky river, the western limit of the eastern coal-field is reached. The coal there, which is a sub-conglomerate coal, is of excellent quality; will average 3½ feet in thickness; and an average sample, taken by Mr. A. R. Crandall, of the State Geological Survey, and analyzed by Dr. Peter and Mr. Talbutt, chemists for the Survey, shows as follows, viz:

Specific gravity	1.307
Moisture	4.00
Volatile combustible matter	35.50
Fixed carbon	55.50
Ash	5.00
Coke	60.50
Sulphur	1.041

This is about the average of the sub-conglomerate coal of that locality. As we ascend the Kentucky river the dip is to the southwest, so that the coals above the conglomerate come in in succession. A preliminary section, from Red river to the mouth of Troublesome creek, establishes the fact that, up to the latter point, there are at least five coals above the conglomerate, ranging from two feet to six feet in thickness. The following table will show the excellent quality of these coals.

The following is taken from Mr. Moore's forthcoming report on that section:

No. 1 is a coal from Frozen creek, Breathitt county. Average sample, taken by P. N. Moore.

No. 2 is a coal from Hobbs' bank, Wolfe county. Average sample, taken by P. N. Moore.

No. 3, Spencer's bank, Breathitt county. Average sample, taken by P. N. Moore.

No. 4, Wolf creek, Breathitt county. Average sample, taken by P. N. Moore and J. R. Procter.

No. 5 from near Hazard bank, Perry county. Average sample, taken by P. N. Moore.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Specific gravity	1.300	1.294	1.297	1.290	1.289
Moisture	2.50	3.50	3.56	2.76	2.10
Volatile combustible matter	41.10	35.20	33.56	36.60	36.20
Fixed carbon	49.22	56.70	58.38	56.50	58.20
Ash	7.18	4.60	4.50	4.06	3.50
Coke	56.40	61.30	62.88	60.56	61.70
Sulphur	0.818	1.189	1.381	0.865	0.836

The cannel coal of the upper Kentucky is to be found over an extensive area, and is of remarkably fine quality, as will be seen from the following analyses by the chemists of the Survey, from average samples taken by Mr. P. N. Moore:

No. 1. George's Branch cannel coal, Breathitt county.

No. 2. Haddock's cannel coal, mouth of Troublesome creek, Breathitt county.

No. 3. Roberts' coal, Breathitt county.

No. 4. Johnson's, Frozen creek, Breathitt county.

No. 5. Lot's creek, Perry county.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Specific gravity	1.280	1.265	1.280	1.180	. . . . .
Moisture	0.94	1.30	3.40	1.20	1.20
Volatile combustible matter	52.38	47.00	34.40	58.80	40.86
Fixed carbon	35.54	44.40	46.96	35.30	46.44
Ash	11.14	7.30	6.24	4.70	9.50
Coke	46.68	51.70	53.20	40.00	57.94
Sulphur	1.423	1.574	0.630	non est.	0.634

Three of the best gas coals in England and Scotland are (No. 1) Lesmahago cannel, (No. 2) Ramsay's New Castle coal, (No. 3) Weyms's cannel coal. See following analyses, which are taken from Dr. Peters' report, vol. 2, 1st series Kentucky Geological Survey:

	No. 1.	No. 2.	No. 3.
Specific gravity	1.228	1.29	1.1831
Volatile matter	49.6	36.8	58.52
Fixed carbon	41.3	56.6	25.28
Ash	9.1	6.6	14.25
Total	100.0	100.0	98.45

Sulphur not determined.

One great objection used to cannel coal as a fuel is its manner of "popping" when first placed in the grate. The Kentucky river cannel is remarkably free from this objection. The high price of cannel coal admits of shipment to distant markets, yet not a bushel of this fine coal finds its way to the Ohio river. We learn there was quite a profitable coal-mining industry on the upper Kentucky until our State locked the river up to Frankfort, so as to afford facilities for Pittsburg coal coming up the river. By an improvement of water navigation to the Eastern Kentucky coal region, coal could be brought to Frankfort for less than ten cents per bushel, and there is no reason why it should not be carried to Louisville and below at much less cost than Pennsylvania coal. At present the boats built to bring coal down the Kentucky river are a total loss to the builders, as there is no way of carrying them up the river. As the boats must come down on a rise, a large number of men are required to handle them, adding to the cost of getting the coal to market. Added to these drawbacks, many boats are lost, owing to the rapidity of the current during the high water, when they are compelled to run.

Notwithstanding these items, adding greatly to the cost of coal, it is frequently delivered at Frankfort at less than the Pittsburg coal. At the rates of freights and lockage on the Monongahela river, the freight on coal, from Three Forks to Frankfort, would be less than two cents per bushel; and as the coal can be put upon boats at the mines at five cents per bushel, the actual cost would not be over seven cents per bushel at Frankfort. The amount of coal consumed along the Kentucky river is over one million and a half of bushels, not counting the amount used in

Central Kentucky, which could be supplied from this river. The cost of freight on canals is one third that of railroads, and yet, paradoxical as the statement must seem, canals are not prejudicial to railroads. The most successful railroads in this country run alongside of canals and navigable rivers

The Eastern Kentucky coal-field extends to the Virginia line. Sufficient is known of the extreme eastern portions to predicate valuable discoveries in that region.

On the upper Cumberland, the work of the Geological Survey establishes the fact that there are several workable beds of coal. An average sample, taken by Mr. J. H. Talbutt, from one of these on the Clear Fork of the Cumberland river, and analyzed by Dr. Peter and Mr. Talbutt, is as follows:

Specific gravity	1,282
Moisture	1.36
Volatile combustible matter	35.80
Fixed carbon	59.54
Ash	3.30
Total	100.00
Coke	62 84
Sulphur	0.975

This coal, excellent as the above analysis shows it to be, is rendered all the more valuable by its close proximity to the rich "dye-stone" ore running along the base of the Cumberland Mountains, in Virginia and Tennessee. An average sample of this ore, near Cumberland Gap, by P. N. Moore, and analyzed by the chemists of the Geological Survey, shows as follows:

Iron peroxide	77.380
Alumina and manganese	3.941
Lime carbonate	.420
Phosphoric acid	.349
Silica and insoluble silicates	15.960
Combined water	2.500
Total	100.520
Metallic iron	54.156
Phosphorus	.149

In 1872 and 1873, owing to the high price of Iron Mountain and Lake Superior ores, the furnaces in Pennsylvania found it profitable to purchase this same "dye-stone" ore in Alabama, ship it from there to Louisville on the cars, haul it to the river on drays, and load it upon barges, and then take it up the Ohio river to the furnaces at Pittsburg. It was also carried from Alabama to the furnaces in the Block Coal Region in Indiana.

This excellent ore is within three miles of Kentucky coal, and the proposed system of river improvement to Cumberland Gap will bring this ore and coal together, and build up extensive iron manufacturing industries.

The ore from Missouri, Lake Superior, and Alabama cost, delivered at the furnaces in Pennsylvania, from $10 to $20 per ton. This excellent ore can be delivered, by way of a tunnel through Cumberland Gap, to Kentucky coal, for from 50 cents to $1 per ton. Improve the navigation on the Cumberland and Kentucky rivers, and pig metal can be manufactured on those streams and shipped to Pittsburg and sold there at a profit at less than it costs to make the same quality of iron there. This is also true of portions of the Green river, where the ore and coals are most favorably associated for the manufacture of cheap iron.

The great Pine Mountain fault extending across the State from Pound Gap to the Eastern portion of Whitley county, brings the level of this ore above the drainage; but it is so covered by the talus from the mountain that the ore has not yet been found. If this ore extends so far west, we can reasonably expect to find it by drifting for it near the base of Pine Mountain.

The dislocations of the rocks in Elk Fork, Tennessee, and the Sequatchie Valley, Tennessee, bring up this ore, and prove that it has a westward extension; and as those disturbances are but an extension of the Pine Mountain fault, the evidence is strong that the ore is in place along the base of the Pine Mountain, and that our State has a large area of this excellent ore, more favorably located with regard to fuel, water-power, and water transportation, which can be easily made available, than in any other section of this country.

Near the Kentucky river, in what is known as the Red River Iron Region, there are several costly furnaces now idle, on account of the difficulties of transportation.

The following is an analysis of the ore, from near those furnaces, average sample taken by Mr. P. N. Moore:

Iron peroxide	75.598
Alumina	1.971
Lime carbonate	.540
Magnesia	.258
Phosphoric acid	.601
Silica and insoluble silicates	8.910
Combined water	11.730
Total	99.608
Metallic iron	52.918
Phosphorus	.262
Silica	7.260

The fame of the Red River car-wheel iron is world-wide. The researches of the Geological Survey make it evident that the ore is coextensive with the sub-carboniferous limestone in Estill, Lee, Owsley, Wolfe, and Menifee counties, so that the proposed improvement of the Kentucky river would not only enable the furnaces in that region, now idle, to run at a profit, but by bringing the coal and ore together, would induce the building of other furnaces. With the proposed canal to the Cumberland river, the Cumberland Gap ores could be brought to these furnaces, making a desirable mixture of ore. I believe that the improvement of these rivers will build up an iron industry second to none in this country.

In 1870 value of pig metal manufactured was—

In Kentucky	$2,182,482
In Ohio	10,956,933
In Pennsylvania	32,632,410

In 1870 Ohio used 379,474 tons of ore more than was produced by her mines, and Pennsylvania used 1,454, 953 tons of ore more than was mined in that State. So that this deficit—more than half the amount used—was brought from other States. In 1872 and 1873 the amount of ore purchased abroad and carried to those States was much greater. The Lake Superior ore is sold on the docks at Cleveland for eight dollars and upwards per ton, and is freighted from there and used in about one hundred furnaces in Ohio and Pennsylvania. Our own State can manufacture as much iron as Pennsylvania without purchasing any ore from beyond its own borders.

A. B. Cornell, Esq., Treasurer of Nimrod Iron Furnace Company, reports the cost of making pig iron at Youngstown, Ohio, in 1869, without interest on investment, was $30 60 per ton.

The cost of making a ton of iron at Carondalet Iron Works, St. Louis, was, in 1869, $32 05, not including interest on investment. [See

letters to St. Louis Democrat, December, 1869, from A. McNary, Secretary of Carondalet Iron Works.]

W. E. S. Baker, Secretary and Treasurer of the Duncannon Iron Works, reports the cost of making pig iron in Central Pennsylvania, in September, 1873, was, without counting interest on capital invested, $34 09, and that this "was below the average of the whole State of Pennsylvania."

We believe it can be demonstrated that pig iron can be manufactured in Kentucky at less than half the above costs. It may be urged that our Kentucky coals are not so good as the coals of other States. This is not the fact. The Indiana Block coal is justly celebrated, and a large and growing iron manufacturing industry has been built upon the merits of those coals. So likewise of the Hocking Valley coals of Ohio.

In Dr. Peter's Chemical Report, page 11, volume 1, second series, the following average of the analysis of twelve of the *best* coals from neighboring States—two from the celebrated Big Muddy coals of Illinois, three from the Indiana Block coal, and seven from the Hocking Valley coal—collected from the most celebrated mines, representing *the best* coals from those States. Compare this with the average of the five coals given on page 19. These samples of Kentucky coals were taken from the outcrop, some of them after long exposure, and certainly do not show those coals at their best.

	Average of 12 coals from Ohio & Indiana.	Average of 4 coals from Ky. river & 1 from the Cumb'land river.
Specific gravity	1.317	1.293
Volatile combustible matter	34.13	34.53
Fixed carbon	56.12	55.80
Per cent. of ash	6.54	4.94
Per cent. of sulphur	1.768	1.017

These coals from the neighboring States are celebrated as iron-making coals, yet good iron ore is much more accessible to the Kentucky coals averaged above. It cannot be said that the Kentucky ores will not make as fine iron, for the excellent metal made in the Hanging Rock iron region of our State, and on Red river and the Cumberland river, attests the capabilities of those ores for making superior iron. Afford transportation facilities, so that the great variety of Kentucky ores can

be brought into communication, and there is no grade of iron that cannot be cheaply manufactured within our borders.

The salt wells on the upper Kentucky river could supply the South and West with that indispensable article, yet not one bushel finds its way to the Ohio river. Should the canal connecting the Cumberland with the Kentucky be built, the tonnage of salt going south would be immense.

Below the Forks of the Kentucky river there is a good hydraulic limestone of quite an extended area. This would not only cheapen the cost of the locks and dams on the river, but a large amount could be manufactured for market after the river is improved.

We have briefly as we could referred to some of the best known undeveloped resources of the upper Kentucky and upper Cumberland region. With development of these many hidden sources of wealth will be brought to light. The agricultural capabilities of this region are much greater than it is supposed to be by persons unfamiliar with it. Now the farmer can raise nothing—owing to the impossibilities of transportation—which he can haul to market, and sell at a profit. The few roads have gone to utter ruin since the war. It is doubtful if a loaded wagon could pass through many of these counties. The improvement of our natural water-ways will not only open up these counties, but will benefit the entire agricultural interests of the State. The agricultural prosperity of China, the Netherlands, and England, is mainly due to the cheap water communication afforded by their canals. With the opening of our mines, manufactories will spring up, creating at once a home demand for all agricultural products.

Joseph Harris, the successful farmer of New York, writes that agriculture is only profitable in that State on account of their nearness to manufacturing centres The canals of New York bring the farmer near to market.

New York has invested in canals $73,440,894. From 1836 to 1873 these canals paid, in *surplus revenues*, $75,048,313.

The amount of indirect gain to the citizens of the State, by affording facilities for commerce, is beyond estimation. Double lines of railroad have been built alongside these canals, yet the tonnage is yearly on the increase.

When we consider the great natural advantages Kentucky has in material resources, and that, for less than *one fifteenth* the cost, our State can have more miles of slack-water river navigation than New

York has of canals, we hardly think any one will doubt the propriety of this State taking vigorous measures to prosecute these river improvements to completion.

In 1775 England had no canals, the first being built to bring to Manchester the product of the mines of one man. So rapidly did these canals extend over the land, that, before the introduction of railroads, there were 2,200 miles of canal in that country, besides slack-water rivers; and in less than sixty years after the building of the first, commercial industries had created a property, inseparable from the soil, to the extent of $1,000,000,000 on canals alone. South of Durham, it is believed, there is not a spot fifteen miles from water transportation. Before the building of these water-ways, England imported from abroad most of the iron used in that island, and at the close of the reign of Charles II the amount of coal mined was no greater than the amount now mined in Kentucky. Now England exports iron to all the world, and with an area of coal-fields smaller than Kentucky, Great Britain mined, in 1871, 117,352,028 tons of coal.

Of what avail are these vast resources, if they are to lie idle. Open ways to them, and countless benefits will accrue to our people; a commerce heretofore unknown will spring up. The consumers of our State, now supplied from other States, will be furnished with cheaper and better commodities by citizens of our own, and the large amount of money annually sent out of the State to purchase foreign productions will be kept at home, enriching the people. The coal and iron and salt and lumber and manufactured products will find ready markets in other States.

IRON ORES AND COALS—ADVANTAGES OF WESTERN KENTUCKY FOR THE MANUFACTURE OF IRON.

BY W. B. CALDWELL, JR.

[From the Courier-Journal, March 9, 1878.]

"The Report of W. B. Caldwell, jr., Metallurgist of the Kentucky Geological Survey, will be found elsewhere in this issue. We bespeak for this exceedingly valuable paper a very attentive perusal. It furnishes an exhibit of some of our most important resources (coal and iron), which, coming from the source it does, cannot fail to attract attention abroad. It is a document which should be printed in pamphlet form and scattered far and wide, in the United States and Europe. Mr. Caldwell is a thoroughly accomplished and experienced metallurgist, his theoretical knowledge having been acquired at the great schools of science and art in Berlin, and his practical knowledge having been obtained in the iron-works of Silesia. He has been engaged by the Chattanooga Steel and Iron Works as the chemist of the establishment, and he will make his headquarters there upon the completion of the steel furnace of the company. This change will not, however, deprive the Geological Survey of Kentucky of Mr. Caldwell's valuable services. In the Northwestern States they trumpet throughout the world their great resources in wheat-producing lands, and keep them ever before the public by means of pamphlets, newspapers, and circulars. We have in Kentucky more durable and valuable resources than those States, and they can only be developed by letting the world know what they are. Our coal and iron region is immense and exhaustless. The facilities for working it are remarkable. We have only to force the facts relating to their abundance upon the attention of capitalists, and our State will be put forward half a century in progress."

Professor N. S. Shaler, Director of Kentucky Geological Survey:

DEAR SIR: I desire to submit the following preliminary report upon the iron ores and coals of Western Kentucky, in regard to their value, more especially for the production of iron. My aim has been to bring into notice what must be an exceedingly important iron district, when

once the industry is started. The previously published reports of the Survey have been of the greatest service in preparing this paper, and my thanks are due the writers; but I must especially acknowledge the kindness of Mr. Jno. R. Procter for valuable information and assistance.

Respectfully,

W. B. CALDWELL, JR., *Metallurgist.*

In view of the fact that iron is down to a point at which furnaces, running with the brightest prospects five years since, can no longer clear expenses, and that capital and skill interested in the industry have been looking for new localities, where the main point may be secured, viz: a profit, however small, I wish to call attention to a deposit of coal and iron undeveloped, and, indeed unknown, except in so far as it has already been brought to notice by the Reports of the Kentucky Geological Survey. These Reports have been the result of careful study of the region by the Survey officers, especially Mr. P. N. Moore, Mr. C. J. Norwood, and J. R. Procter, who have located the ores and coals, and sent samples to the chemists, Dr. Robert Peter and Mr. J. H. Talbutt, the result of the investigations being undoubted evidence that the State of Kentucky possesses, in her western iron and coal field, an amount of undeveloped wealth of too great importance to be overlooked. There remains, however, much work to be done in Western as well as in the rich coal and iron regions of Eastern and Southeastern Kentucky, and just at this time it is of especial importance; for these districts should be brought to the notice of capital seeking such investment. A few thousand dollars spent by the State in proving her wealth and advantages, is insignificant in comparison with the hundreds of thousands which should come from the East to develop the iron and coal.

After giving a short account of the coals and ores, which are fully described, with analyses, in the Survey Reports, I will consider two or three points in the Western coal field, possessing unusual advantages for the iron industry; but there are others which may be found to possess as great or greater.

It will be acknowledged by all that the following are the essential points for the production of cheap iron: a good coking coal, which can be cheaply mined and handled; abundant supply of iron ore, sufficiently rich and pure, lying contiguous to the coal, or which can be brought to it at very low rates; pure limestone; cheap labor of a good

class; abundant water supply; and low freight to a good and near iron market. These advantages are possessed, to an unusual degree, by Western Kentucky, as the following facts and figures will show, and comparison with some other localities claiming to be the cheapest iron regions in the world.

COALS.

An outline description of the coal field is given by Mr. Norwood in the Survey Reports, with numerous analyses by Dr. Peter and Mr. Talbutt; but our Survey officers have been, in many cases, strict in taking samples; for in many of the coal veins the sulphur occurs (as pyrites) in heavy partings, and would be thrown out in mining; whereas, they have taken the entire vein as it comes, thus making the per centage of sulphur strictly correct as it lies in the bed, but higher than it would be in the coal with ordinarily good mining. For this reason the analyses show more sulphur than is given by other Geological Survey analyses of similar coals, which, when sampled by the same person who sampled Kentucky coals, showed as much sulphur.

The Kentucky coals give an excellent coke, bright and firm, and even those highest sulphur would give, when washed, as good coke as the celebrated Connellsville. Coal washing is now so generally practiced, and can be done so cheaply—less than ten cents per ton—washing three or four hundred tons per day, that it will certainly be done in Western Kentucky, and the coke will then be unexcelled.

The western coal field embraces about 4,000 square miles, and contains twelve veins, mostly workable, some at one part of the basin, others at another. Perhaps it would give a better idea of the extent of the coal field to say that it takes in nine counties entirely, and parts of five others. The coal can be mined along the railroads by shallow shafting, striking Nos. 11 and 9; but at a short distance from the road the hills allow drifting, as at the Crabtree, Paradise, and many other mines.

The industry is growing rapidly, and the city of Louisville already uses large quantities of this coal, thus keeping in the State thousands of dollars which would go to Pennsylvania; but, what is vastly more important, the price of coal is kept at a low figure, enabling our manufactories to live, and the mines employ hundreds of men, to whom at least half a million dollars yearly are paid out.

The old Reports by D. D. Owen used numbers to designate the veins, beginning with the lowest in the series; but the new Reports, by Professor N. S. Shaler, begin at the highest coal, and use letters; thus Coal *A*, of the new Reports, corresponds to No. 12 of the old series.

The most important of the upper coals, so far as experience would indicate, are A, B, and D, or, by Owen's numbering, 12, 11, and 9.

Of these, No. 12, or A, the highest workable coal in the series, was worked by Mr. Alexander at Paradise, on Green river, twenty years ago, but is not mined now. It is a bright, hard, bituminous coal, which gives an excellent coke. A sample of coke made at Airdrie Furnace twenty years ago, and exposed to the weather ever since (see Mr. P. N. Moore's Report of Airdrie Furnace Property, vol. 2, new series), gave the following analysis:

	Per cent.
Moisture at 212°	7.50
Moisture at redness	4.20
Fixed carbon	82.90
Ash	5.40
	100.00
Sulphur	0.64

This is probably as pure as any coal in the basin, and compares favorably with any soft coal in the country. A sample taken, as usual, the entire thickness of the vein, including everything, gave—

	Per cent.
Moisture	4.15
Volatile combustible matter	33.14
Fixed carbon	55.71
Ash	7.00
	100.00
Sulphur	1.87

The vein can be mined at Airdrie by drifting.

Next below this coal comes B, or No. 11, a very persistent vein, six feet thick; a good, bright coal, but containing slightly more sulphur than No. 12. It is the coal mined by Gen. Buell at Airdrie, on Green river, and also by several companies along the railroads.

An average of samples, taken the entire thickness of the vein at Paradise, gave—

	Per cent.
Moisture	2.25
Volatile combustible matter	41.54
Fixed carbon	50.62
Ash	5.64
Sulphur	2.98

A lot of slack from St. Bernard mines, Earlington, Kentucky, No. 11 coal, washed and coked, gave a good, bright coke, with 1.06 per cent. sulphur, showing that even the refuse, when washed, makes a good coke.

The next coal of importance is D, or No. 9. This is probably the most persistent and uniform coal of the series; is from four to six feet thick, averaging five feet, but contains more sulphur than 12 or 11. It is, however, an excellent coal for grate and furnace, and gives a good

coke. A lot of slack from this vein, from St. Bernard mines, Earlington, Kentucky, washed and coked, gave a bright, firm coke, with only 1 per cent. sulphur. In some places coals 8 and 7, or E and F, are from four to five feet thick, and of unusually good quality; but, generally speaking, the coals below 9 are not important in regard to the subject of this paper, until we come down to L (or No. I B, of Owen), a hard, bright coal, resembling somewhat the Indiana "block coal" in appearance, and giving a very similar analysis.

Coaltown Bank, Christian county, gave—

Moisture	4.85
Volatile combustible matter	32.22
Fixed carbon	55.03
Ash	7.90
	100.00
Sulphur	1.37

Sample of Indiana block coal gave—

Moisture	2.68
Volatile combustible matter	36.32
Fixed carbon	53.58
Ash	7.42
	100.00
Sulphur	1.80

Sample from Edmonson county—

Moisture	4.06
Volatile combustible matter	33.24
Fixed carbon	51.70
Ash	11.06
Sulphur	1.67

With an unlimited supply of coal of excellent quality for iron-making, and as cheaply mined and handled as this may be, with transportation facilities by rail and river unequaled by any iron region, it only requires, to prove the existence of abundant supplies of iron ore of sufficient richness and purity, to show that this must inevitably be a great iron-producing region in the future; for its nearness to several markets, especially Louisville, gives it great advantages over more distant points, where iron might even be made at a lower figure.

IRON ORES.

The ores are exceedingly numerous and varied in character, from material almost too lean to be called ore, up to rich, pure, brown hematites or limonites.

They may be divided into two classes:

First. Coal-measure ores, which occur in the coal-bearing formations, either stratified with them, and having great extent, or confined to one locality as local deposits or pockets.

Second. Limestone ores, occurring below the coal, in the limestone of the Sub-carboniferous, as in Caldwell, Lyon, and Trigg counties, along the Cumberland river, where a very pure, rich, brown hematite occurs in the form of pot-ore. A brown hematite ore of good quality occurs in the Chester Group in Edmonson county.

COAL-MEASURE ORES.

The coal-measure ores are so numerous that it would be useless to attempt a full description of them here (as they are fully described in the Survey Reports), so I will only describe a few prominent ones, stating, however, that those mentioned are not necessarily the best, but they happen to be convenient for transportation to points which will be mentioned later as good locations for furnaces.

These ores occur principally in Muhlenburg and Edmonson counties. In Edmonson, between the Nolin river and Bear creek, a ridge about fifteen miles long and five miles wide, carries several beds of good ore, altered carbonates probably, which appear as limonites on the outcrop, but may run into carbonates when sufficiently under cover. There was a charcoal furnace in this locality formerly, and samples from two of their old mines or banks show the good quality of the ore:

	First per cent.	Second per cent.
Metallic iron	40.48	36.50
Water	12.18	8.90
Silica	14.36	17.82
Phosphorus	0.41	0.21
Roasted ore gives metallic iron	46.10	40.00

An excellent ore, occurring between two branches of Sycamore creek, in the same locality, but a limited deposit, gives—

	Per cent.
Metallic iron	53.40
Silica	7.66
Phosphorus	0.46

A bed of ore, called "Federic Bank," is very similar to first and second old Nolin Furnace banks, in composition and character, except that it is much higher in silica, on the outcrop at least:

	Per cent.
Metallic iron	42.31
Silica	22.40
Water	10.29
Lime	1.21
Alumina	4.83
Phosphorus	0.28

This being over three feet in thickness, could be mined very cheaply, and is only a short distance from water.

In Muhlenburg county there are many ores of excellent quality, accessible by rail or river, and easily mined.

On the farm of J. M. Hope, on Mud river, is an outcrop several feet in thickness, running through a ridge and cropping out on the other side, about a mile distant. Leaving out the upper two or three feet of the bed, which is most silicious, the other part, some four or five feet thick, gives—

	Per cent.
Metallic iron	45.10
Alumina	6.98
Water	12.31
Silica	14.20
Phosphorus	0.39

This is probably the same ore as the Federic Bank, Edmonson county, and the indications are that this ore extends over a very wide area, cropping out wherever its geological position would bring it to the surface.

Near Greenville, about three miles from the Elizabethtown and Paducah Railroad, is a deposit some eight inches thick of an excellent ore, which could be easily mined for $1 25 per ton, as it would have to be done by stripping. Most of the ores in the celebrated Hocking Valley, Ohio, region are mined in that way at that price; indeed, few ores in that region are of greater thickness, and scarcely any of them so good as this ore near Greenville, which gives—

	Per cent.
Metallic iron	48.88
Alumina	3.91
Water	11.25
Insoluble	12.73

Over No. 12 coal occurs an ore called Blackbank, about 12 inches thick, which is a slightly bituminous carbonate, giving a limonite on the outcrop. A sample taken from the bed (analysis 1) and a sample from roasted stock-pile, at Airdrie Furnace, weathered twenty years (analysis 2), gave as follows:

	First per cent.	Second per cent.
Metallic iron	44.13	43.12
Alumina	5.29	3.10
Water	12.43	. . . . .
Insoluble	17.25	25.40
Lime	. . . . .	3.01
Magnesia	. . . . .	4.58
Phosphorus	. . . . .	0.23

There are very many other coal-measure ores which are valuable and accessible; but enough has been mentioned to show their number and good quality. Silica is rather high, but they fortunately carry considerable alumina and lime.

The Cumberland river or limestone ore is the most valuable and important in the region, as there is an inexhaustible supply accessible by rail and river, and the quality such as to have already given it a high reputation. The amount of phosphorus varies from 0.065 per cent. up to 0.19 per cent., the variation apparently not dependent on other impurities. The per centage of iron also varies somewhat, as some of the beds contain considerable chert; but this can be largely separated by careful mining, and give an ore with fifty per cent. metallic iron. The ore occurs as broken masses of "pot" and "kidney" mixed with chert rock, in immense beds or masses, and is mined by quarrying very cheaply. Such a deposit is cut by the railroad at Kuttawa, and a sample taken by Mr. Moore, an average of the bed, gave analysis (1). A sample taken by myself, of the ore as it would be mined, leaving out lumps of chert, gave analysis (2). Samples 3 and 4 were taken from an old bank used by the old furnace—3 taken by Moore, an average of bed; 4 by myself, showing ore as it should be mined; 5, analysis by Otto Wuth, of Pittsburg, of same ore from near Princeton, Caldwell county.

ELEMENTS.	PER CENT.				
	First.	Second.	Third.	Fourth.	Fifth.
Iron oxide	66.12	69.80	. . . . .	71.20	69.46
Alumina	1.06	2.98	. . . . .	3.01	3.75
Lime	. . . . .	2.12	. . . . .	2.87	4.16
Magnesia	. . . . .	1.72	. . . . .	.65	1.54
Water	9.80	10.83	. . . . .	9.83	10.98
Silica	22.33	11.98	18.91	12.10	8.97
Metallic iron	46.28	48.86	49.36	49.84	48.62
Phosphorus	0.18	0.09	0.12	0.09	0.07

In Trigg county, near the old Center Furnace, a sample taken from one of the old banks gave—

	Per cent.
Metallic iron	50.195
Water	9.630
Silica	16.960
Phosphorus	0.095

Several other analyses, made by myself for phosphorus, show that this *bete noir* of the iron industry varies in these ores from different parts of the bed, but no analysis gave over 0.2 of 1 per cent.

In regard to locations well adapted for furnace sites, there are many which promise well; but I will only consider two or three, the advantage of which can be easily shown.

One of the most prominent of these, Airdrie Furnace, on the bank of Green river, three miles above Rockport, the crossing of the E. and P. R. R., has been described by Mr. P. N. Moore in his report on Airdrie Furnace Property, vol. II, Kentucky Geological Reports. The furnace was built and properly improved by Mr. Alexander, twenty years ago, at great cost, and has been a serious injury to the region, as the enterprise was an utter failure. This was, however, owing to the ignorance and mismanagement of the superintendent, who attempted the use of raw coal with the silicious ore overlying No. 12 coal, and failure was almost inevitable on a hot blast. Having made one attempt and failed, the next step should have been to coke the coal, and mix some better ore with his black band; but the furnace was blown in three times on raw coal and black band ore, and, after a total run of six weeks (in all, three campaigns), the proprietor closed the works. The iron made was silver-gray, with from 5 to 10 per cent. silicon, and about 0.40 per cent. phosphorus.

This would be an admirable starting point for the iron industry of the region, as it would require comparatively little capital to put the entire plant in running order. The improvements are: a stack (blast furnace) in good condition, of the following dimensions: height, fifty feet; diameter bosh, seventeen feet; open top, no down takes for gases; pipes, still in good condition, of old hot-blast stoves; four steam boilers, twenty-eight feet by forty inches; blowing engine, vertical, steam cylinder below, twenty inches in diameter, nine-foot stroke; blast cylinder, six feet ten inches in diameter, nine-foot stroke, all in good condition in a good stone building; four hundred feet shaft, with engine for raising material, coal or ore, the shaft cutting through No. 9 and No. 5 coals—No. 9 being five feet thick, and No. 5 3½ feet—and said to strike a four-foot vein of ore, supposed to be same as Hope ore, of Edmonson county. The top of the furnace is on a level with the No. 11 coal, and No. 12 was brought, by a short tunnel, to the same mine entrance, the entry being within thirty yards of tunnel-head. To put the plant in running order, and make some modern improvements, should not cost over $40,000, if so much, and a company starting here could obtain the use

of furnace plant and mineral rights on the most reasonable terms from General Buell.

They would start with the great advantage of having, already for use, roads, laborers' houses, etc.; mines, being worked, producing four or five thousand bushels of coal per day; a stock pile of several thousand bushels of coke and roasted ore, etc.

The situation on the river bank opens the entire Green River Valley to it, and the E. and P. R. R. crossing, only three miles distant, at Rockport, gives every facility for transportation.

Thus we see that the location has a great extent of ore-bearing country tributary to it, and, as the ores are very varied, the furnace could receive any mixture desired. Of course, experience and the market demand would show whether it would be more profitable to use impure coke and cheaper, poorer ores, and produce a cheaper grade of iron, or to wash the coal before coking and select better ores, although more expensive, and produce a higher grade of iron. Certain ores are adapted for certain grades of pig metal, and it is generally a great mistake to attempt to use them for anything else; but it is a mistake which is only too frequently made.

As regards the cost per ton of iron which could be made at this point, running on several different mixtures, the following figures will show that profit can certainly be made. Assuming that No. 12 coal would be used, which would be best, unless No. 11 were washed, the coal and ten-inch carbonate ore above it could be mined together—say, coal 75 cents per ton as it comes, and ore the same price.

Three tons coal to two tons coke would make $1 12½ per ton; 25 cents per ton for coking, $1 37½ per ton; then, assuming the use of two tons coke, which is higher than it should be, the coke would cost $2 75 per ton of iron produced.

The carbonate ore should be roasted, which could be done for 25 cents per ton, with 75 cents for mining; this would make $1 per ton.

The J. M. Hope ore, Mud river, could be mined for seventy-five cents, as it would be the simplest mining possible, and a small lock and dam in Mud river would run slack-water to within a very short distance of the bank; the ore could then be taken by barges to Airdrie for seventy-five cents, handling again twenty-five cents, making cost per ton $1 75—say $2, to make it sure. Using a mixture, then, of one ton carbonate (or call it black band for distinction) and one and one half tons Hope ore, the cost per ton of iron would be—

Two tons coke	$2 75
One ton black band	1 00
One and one half tons Hope ore	3 00
Three quarters ton limestone	75
Labor and incidentals	3 00
Total	$10 50

To put this on the cars at Rockport at fifty cents per ton, and freight to Louisville, say $1 50, makes $12 50 at Louisville. The poorest mill iron would be profitable at this figure, whereas, the mixture used should give a very good grade of foundry or mill.

If this mixture did not work well, however, an expert furnace man would know what the trouble was, and would try other mixtures, of which he could have as many as desired from the Green River Valley, some costing less, others more, than the Hope ore.

The Cumberland river ores are only from fifty to sixty miles distant by rail, and the freight would not be over seventy-five cents per ton to Rockport; transfer to barges by chute and taken to furnace would cost about twenty-five cents, making $1; and, as they could be mined and put on the cars for $1 75 or $2, these ores would cost $3 at the furnace. They yield, at the lowest average, forty-six per cent. metallic iron, and, consequently, one and a half tons would suffice to mix with one ton black band ore; then two tons coke, $2 75; one ton black band, $1; one and a half tons Cumberland ore, $4 50; three quarters of a ton limestone, seventy-five cents; labor and repairs, $3; cost at Louisville, $2; makes $14 per ton at Louisville for an iron which should bring a good price at Louisville.

Using all Cumberland river ore, an iron could be made low enough in phosphorus, if the ores were properly selected, to make such low grades of steel as are used for agricultural implements and many kinds of small articles. The cost per ton of such an iron would be: two tons Cumberland river ore, $6; two tons coke, $2 75; three quarters of a ton of limestone, 75 cents; labor and repairs, etc., $3; freight to Louisville, $2; total, $14 50.

Three grades of iron have been mentioned, costing at Louisville $12 50, $14, and $14 50, respectively. Now, assuming that incidental expenses would run this cost up somewhat, as it invariably does—although I have tried to put it so that the estimates would be fair—suppose we add twenty per cent. to each figure; the iron would then cost at Louisville $15, $16 80, and $17 40.

These figures would insure a profit of at least $2 per ton, which very few furnaces in the United States can make to-day.

Assuming an output of thirty tons per day, this would give 10,900 tons per year, at $2 per ton; profit, $21,900 on an outlay of not over $50,000.

Referring to the Hocking Valley iron region of Ohio, described by Mr. Pechin in the Metallurgical Review for September, October, and November, the comparison with Western Kentucky is most favorable to the latter.

The iron world was apparently crazed in regard to this valley; for in a very short period—about three years—some ten or twelve furnaces have been built and projected, mines opened, etc., at enormous expense, and one need only read Mr. Pechin's article to see that they went too fast. In the first place, several of the furnaces were compelled to blow out during the past summer for lack of water for boilers and tuyeres, etc. The only real advantage which the valley has is an abundant supply of good coal, which is, however, no purer than that of Western Kentucky.

The ores are nearly all less than one foot thick, and analyses show them often very lean and quite high in phosphorus.

The two principal ores are the Baird and Shawnee, the Baird being only from six to fourteen inches thick, and varying very widely in quality in different localities—metallic iron from 30 to 45 per cent., silica running as high as 25 per cent., and phosphorus from 2 or 3-10 of 1 per cent. to 1 per cent. Shawnee is thicker but not better, and, as Mr. Pechin says, "its exhaustion by the four furnaces at Shawnee is a question of but few years." The cost of making iron in the Hocking Valley, at different points, as given by Mr. Pechin, is—

	Thomas Furnace.	Fannie Furnace.
Three tons coal, at 75 cents	$2 25	$2 25
Three tons ore, at $2 25	6 75	(at $2) 6 00
One ton limestone	1 25	(¾ ton) 60
Labor and repairs	4 00	4 00
Total	$14 25	$12 85

to which freight must be added.

The Baird Furnace, with coal at the furnace and ore only half a mile distant, finds the iron to "cost $13 on paper, but really nearer $15 on the cars;" but the ore is only eight inches thick, and costs $1 25 to mine; then it must be loaded and hauled half a mile, and the iron must be hauled to the cars. There is not such an ore in the Hocking Valley as the Cumberland river, the Hope, or the ore of Edmonson county.

The coke furnaces of Alabama, Georgia, and Tennessee, making such grades of iron as I have mentioned, cannot possibly make it for less than it could be made in Western Kentucky, and then the latter has the advantage of at least $1 per ton freight; and on an outlay such as would be necessary at Airdrie, $1 per ton would be a good profit.

Another locality which promises most favorably is the district between Nolin river and Bear creek. Here is every advantage for iron-making, except railroad transportation, and in these times of narrow-gauge roads, it would not be impossible to run a road through the region, say from Grayson Springs to some point on Green river; or extend the projected road from the L. and N. to Mammoth Cave, six or seven miles further, to these ores and coals. Leaving the railroads out of the question, however, very little expense on the water-courses—one lock and dam—would give good water transportation, and pig-iron could be taken to Rockport, Bowling Green, or Evansville, on the Ohio river, at a very low figure. Slack-water navigation can be reached by a tram-way of a few miles in length from the centre of this region.

Some of the most prominent ores of this locality have already been mentioned (page 6). They can be mined for less than one dollar, and by locating a furnace conveniently for both ore and coal, which could easily be done, iron could be made at a very low figure.

The coal, being unusually firm and hard, could be used raw to the extent of at least one third, and as the vein—Main Nolin coal or L—is 3½ feet thick at the least, mining could be done for 75 cents, as it would be on the drift.

COST PER TON.

Two tons coke	$2 75
Two and one half tons ore	3 00
Three fourths ton of limestone	75
Labor, repairs, &c.	3 00
Hauling to river and freight to Rockport	1 50
Freight to Louisville	1 50
Total	$12 50

This region abounds in the best timber for charcoal, and as the freights are a good part of the cost of this iron, a high-priced iron, such as a cold-blast charcoal, would probably be as profitable as anything that could be made in the region.

CUMBERLAND RIVER ORES.

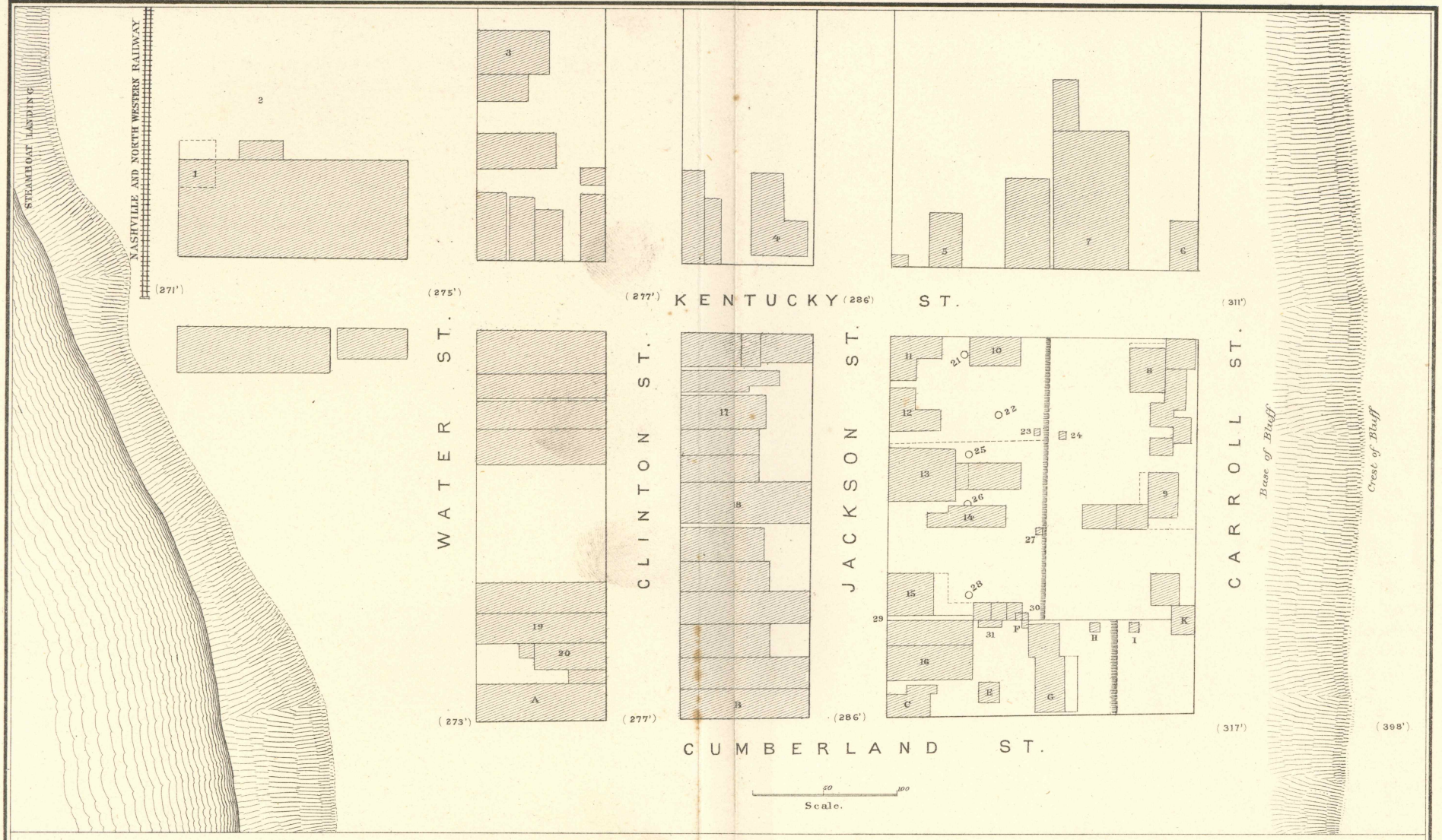
These ores have already a high reputation, from the celebrated boiler-plate of D. Hillman & Sons. By locating a furnace at some one of the many banks on or near the line of the E. and P. R. R., between Prince-

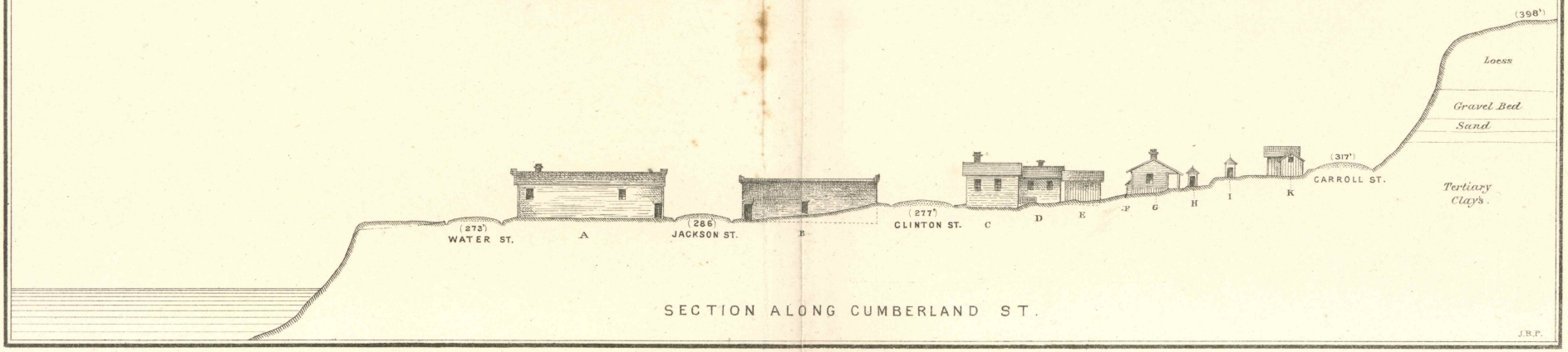
ton and Kuttawa, selecting an ore low in phosphorus, an iron could be made which should be very profitable. The coal mines are from twenty-five to forty miles from these ores; and by coking the coal at the mines, loading it on to cars and shipping to the furnace, it should not cost over $2 per ton for coke. The ore can easily be mined for one dollar. Then

Two tons coke	$4 00
Two and one fourth tons ore	2 50
Three fourths ton limestone	75
Labor and repairs, etc.	3 00
Freight to Louisville	2 00
Add 20 per cent incidentals	2 45
Total	$14 70

cost per ton put down at Louisville for a grade of iron which ought to bring a high price, being very low in phosphorus

Although these are paper estimates, I feel sure that they will be found reasonably correct, when the line of the Elizabethtown and Paducah Railroad is alive with the busy hum which is always found in districts producing iron, as this region will surely do at some time; and it would be wise in our State to bring to notice, as much as possible, a source of wealth to those investing, and one which would be still more a stimulus to the prosperity of several counties. Blast furnaces require the opening of coal and iron mines, and these require the labor of many men; these men must be fed and clothed, houses must be built for them, and in various ways does the industry react advantageously upon the surrounding country. The Geological Survey is at present working to show the world what sources of mineral wealth our great State possesses, as well as to point out the quality of her soil, the character of timber which nature has so lavishly donated her, and in every way possible to produce an index, so to speak, which may be consulted and relied upon.


STEAMBOAT LANDING
NASHVILLE AND NORTH WESTERN RAILWAY
(271')
(275')
(277')
KENTUCKY
(286')
ST.
(311')
WATER ST.
CLINTON ST.
JACKSON ST.
CARROLL ST.
Base of Bluff
Crest of Bluff
(273')
(277')
(286')
(317')
(398')
CUMBERLAND ST.
50
100
Scale.


(398')
Loess
Gravel Bed
Sand
Tertiary Clays.
(317')
CARROLL ST.
(273')
WATER ST.
A
(286')
JACKSON ST.
B
(277')
CLINTON ST.
C
D
E
F
G
H
I
K
SECTION ALONG CUMBERLAND ST.
J.B.P.

REFERENCES TO PLATE I

1. Railway Depot and Telegraph Office: marsh under large Building.
2. Open Lot, flat and marshy.
3. Fulton House (lot No. 10, map); eleven cases of fever and four deaths in this house. (See tabulated statement of cases, page 76.)
4. Thos Gleeson's residence; three cases and one death. (See page 75.)
5. Blacksmith Shop; A. Seymour and Gustave Hunsacker, and all of the negro hands, attacked early. (See No. 20, page 74, tabulated statement.)
6. A. Young; every member of family (seven in number) had fever; five died. (See Nos. 21 to 27, page 74.)
7. Livery Stable; occupant left early.
8. Occupants left early.
9. Six cases and two deaths. (Nos. 10 to 15, page 74.)
10. Five cases (negroes); all recovered; probably the first case among the negroes was in this house
11. Four cases (negroes); no deaths.

12 and 13. Negroes; nearly, if not all, had fever; 13 is where the Band practiced. (See page 75.)

14. Old Stable Shed.
15. Tenement-house, occupied by negroes; all remaining, had fever.
17. Every member of family—six—died (See No. 30, page 75.)
18. Sampse & Son furniture store; both died; other stores on block vacated early.
19. Reed family occupied second floor (See Nos. 105–'6–'7 and Appendix C.)
20. Mangel's Bakery. (See Nos. 7, 8, and 9, and No 57; also see reference, page 71.)

21, 22, 25, 26, 28. Cisterns.

31. Tank back of Cooper Shop.

A. (Plat and section.) Drug Store; only clerks remaining died. (See No. 95, page 76.)

B. N. P. Harness & Co, Hardware Store; he died (See No. 41.) Partner and clerks left early and escaped.

C. Occupied as offices; Dr. Catlett's office was in this building, on ground floor, rear portion.

D. Undertakers and E. D. Case's Cooper Shop. (See No 16, page 74.)

E. Stable; very damp and unwholesome.

G. Hendricks House, where first case occurred; six cases and five deaths in this house. (See No. 1. page 74.)

K. Stable and Pig-sty.

NOTES

ON THE

YELLOW FEVER EPIDEMIC

AT HICKMAN, KENTUCKY,

1878.

BY JOHN R. PROCTER.

PRELIMINARY NOTE.

In the "General Account of the Commonwealth of Kentucky," published in the second volume of the Reports of Progress of the Survey, new series, attention was called to the immunity from yellow fever which had happily characterized its history. It is now necessary to qualify this statement; for, as is well known, this disease found a foothold within the Commonwealth during the epidemic of 1878. Although we can no longer claim that our territory has escaped this plague, we may still find justification for the opinion that the conditions of its soil and climate are such as will enable us to secure ourselves against its ravages by the use of the most ordinary sanitary precautions. While the fever was epidemic in Memphis, the seeds of the disease were sown broadcast all over the central and western districts of Kentucky. At only two points —at Bowling Green and at Hickman—did the disease fairly plant itself upon our soil. At Bowling Green it found a nest in a small and very foul group of dwellings near by the railway station, where trains containing thousands of refugees, many of them suffering from the disease, were halted for meals. At this point about 25 cases occurred; yet the malady showed no tendency to spread from the pestilential settlement, where it broke out, to the better drained town of which it formed a part. In Russellville, Hopkinsville, and a score of other towns on the railways connecting directly with Memphis, in all of which there is much to desire in the way of better drainage, the thick sown seeds of the fever failed to germinate. Even in Columbus, Kentucky, a town with conditions of position somewhat resembling Hickman, the fever never has found a foothold. These facts prove that the general physical conditions found within the territory of Kentucky are very unfavorable to the spreading of this disease.

The history of the several epidemics of yellow fever in this country shows that, with similar opportunities for infection, the towns of our Atlantic coast, from Maine southwards, would not have escaped so easily. There is some reason to believe that this disease ravaged the Indian tribes of the coast, from the Merrimac river southwards, just before the settlement of the country by the whites. In the various epidemics of the last two centuries Boston, New York, and Philadelphia have suffered from it. Mr. Procter's report shows that, during the epidemic of last year, the disease found a foothold in the State of Ohio, much north of Kentucky territory. These facts make it evident that the position of Kentucky, near the centres of infection which have been repeatedly developed, does not necessarily mean a greater danger of its attacks than threaten more northern localities. It is evident that a very little

care to the important matters of drainage and water supply would remove the risks of infection which we now run. These sanitary questions, already the most important of our social problems, are sure to increase in gravity with the constant growth of our city population. It is not, however, from the need of protecting ourselves against the ravages of yellow fever and cholera, which are essentially foreign diseases, from which we may hope in time to be protected by quarantines, that these questions of drainage and water supply have their greatest importance. We have to contend with maladies in the shape of typhoid and other fevers, common to the whole country, which we know to be essentially filth diseases, that may be escaped from by a close attention to these sanitary matters. Nearly one half the deaths in our population, and an even larger proportion of the illness of our people, are due to bad drainage and the poisoned drinking water that comes from bad drainage. No despotism ever imposed such a tax as this burden of disease and death that is laid upon all peoples by their negligence and ignorance in the way of cleanliness. Even from a money point of view, our avoidable disease and death are the greatest loads that our modern civilization has to bear. It is demonstrable that it costs a thousand dollars to raise an average human being to adult life. There can be no reason to doubt that a State loses, on the average, a property of this value with every death of a citizen; and if we could reckon the loss from illness, the disruption of families, and the disturbance of other relations, the cost for every death would double this amount. Measured on this basis, which I feel sure is within bounds, the money loss of the State at Hickman in the epidemic of 1878 exceeded two millions of dollars. That this seems a very great sum is due to the fact that we have not become accustomed to reckon human life as immeasurably the most costly of all the products of society; yet such indeed it is. The capital that is put into each generation of men vastly exceeds all that enters into our houses, railways, and other investments of labor. It is less expensive to the State to burn down a city and rebuild it several times than to let its life be consumed by a pestilence.

The matter of drainage is as much a geological as an engineering question. It has, therefore, seemed to me desirable that this report of Mr. Procter should find a place in the records of the work of the Survey. The present Geological Survey of Kentucky has several times found itself compelled to take up questions that at first sight might seem to lie a little apart from the path marked out for it by its name. In this as in other cases, they have been warranted by the several laws controlling the Survey, which have made a bureau of information concerning the physical resources of the State.

N. S. SHALER.

NOTES ON THE YELLOW FEVER EPIDEMIC AT HICKMAN, KENTUCKY, 1878.

BY JOHN R. PROCTER.

Hickman, the county seat of Fulton county, Kentucky, a town of about 1,500 inhabitants, is situated in latitude 36° 34′ 19″, and longitude 89° 11′ 42″, on the eastern bank of the Mississippi river, thirty-eight miles below its confluence with the Ohio river at Cairo.

The Mississippi cuts its shifting course in a flat alluvial plain of from forty to seventy miles in width, extending southward from Cape Girardeau, in Missouri, for more than eight hundred miles, bounded by parallel escarpments of about two hundred feet high. At Columbus, Hickman, Memphis, and Vicksburg the river swings against the eastern wall of this great plain.

Here the river changes its southward course in a grand sweep to the westward, leaving the Hickman bluff a conspicuous promontory, commanding an extended view of the river and densely wooded plain.

Approaching by river from either direction, the pretty town of Hickman, crowning the hills with shade-embowered residences, with the substantial business houses clustered around the base on the lower level, offers a most attractive scene to the eye, long wearied with the monotonous flatness of the bordering plains.

The bluff presents to the river front a vertical escarpment, the talus at the base sloping into the level of the plain below. From the crest, which at the highest point is two hundred* feet above the low water level, the plateau slopes gradually away to the eastward. These east-

*This elevation is only approximately correct, and was arrived at from the following data: low water at Cairo is given by Ellet ("Ohio and Mississippi Rivers" Philadelphia, 1853) at 275 feet. A survey from Hickman to New Madrid by F. Heller, C. E., made the fall in the Mississippi river 0.5 foot per mile. The level of low water in the Mississippi, at the mouth of the Ohio, was ascertained by Mr. John Childs engineer of the Mobile and Ohio Railway, to be 275 feet. Low water at St. Louis, as established by survey of Mr. E. Guest, engineer of the Ohio and Mississippi Railway, is 418½ feet above sea level. This would give an average inclination of 8½ inches per mile between Cairo and St. Louis. Assuming therefrom an inclination of 6 inches per mile between Cairo and Hickman, we get 256 feet as the proper elevation above tide, at low water mark at Hickman. Ellet places the descent of the Mississippi river below Cairo at 2.8 inches per mile, which would give a greater elevation at Hickman. The levels in the town of Hickman were obtained from careful surveys, made for grading the streets by F. Heller, and by barometic observations made by myself. The elevations are as much as the contours and figures show on the map. Assuming that the descent is only 2.8 inches per mile, then ten feet should be added to the elevation of each contour on the map, which would place the top of the bluff 470 feet above sea level.

ern slopes are cut and rounded by the drainage, which is away from the river, into a picturesque topography.

The town is divided into three parts: all west of Obion street being West Hickman; east of Allegheny street, East Hickman; and between those streets, Hickman, which latter division comprises all of the business portion of the town, and many residences on the bluff, as will be seen by reference to the map accompanying this Report.

No place within my knowledge has a better natural drainage, or is more cleanly and salubrious, than Hickman on the hills. In West Hickman the drainage is away from the river; so that water falling within a few feet of the river bank drains into a small creek, which, after miles of sluggish wanderings, finds its way into Reelfoot Lake. This sloping of the plain away from the river is a peculiarity of the Mississippi bottom lands.* It will be seen, by reference to the contours on the accompanying map, that West Hickman is very level. So, also, is a portion of Hickman. The streets of Hickman are paved with a gravel taken from the bluff above the town similar to the gravel used at Paducah, and is the finest street material I have ever seen. The streets are well graded, with gutters on either side, and are always clean. Rains, instead of producing mud, as upon our limestone macadamized roads, only wash them the cleaner. In constructing the streets, they were raised several feet higher than the land, and no gutters or *drains under* the streets were provided; so that water falling on the several squares of the town has no escape but by evaporation and sinking into the earth, a method of escape rendered difficult, as we will find on an examination of the formation on which the town is built.

The upper portion of the bluff (see Plate I) is composed of a homogeneous buff-colored silicious loam, from forty to fifty feet thick, known among geologists as the "Bluff" or Loess formation (20 b. of Dana's Table of Formations), which is, with the exception of the alluvial river bottoms, the most recent of the Kentucky formations. In appearance it resembles a compacted dust, and has by some† been thought to have been formed from the detritus of underlying and neighboring rocks, swept into its present position in the form of dust by atmospheric agencies. Abundant evidences are found at Hickman and other parts of Western Kentucky where this formation is present, that it is a fluviatile or diluvial deposit. Probably owing to the presence of numerous land and fresh water shells (*Helix, Cyclostoma Pupa, Cyclas, &c.*), this

*See volume 3d, page 70, for a map showing the general character of such drainage.
†See Geology of Mississippi: Jackson, 1857, p. 283.

formation is highly calcerous,* and in the lower part concretions of lime are found.

This bluff loam rests upon a bed of coarse gravel (12 a of the Tennessee Reports, and the equivalent of the "Orange Sand" of the Mississippi Reports), which is about ten feet thick. This gravel underlies the bluff loam, throughout that portion of Kentucky west of the Tennessee river, varying in thickness from a few inches to thirty feet; the pebbles sometimes wanting, and the formation represented only by a thin streak of orange-colored sand.

This gravel bed is composed mainly of rounded water-worn pebbles of quartz from the carboniferous conglomerate, and water-worn angular pebbles of chert and hornstone from the Keokuk and Corniferous groups, and coarse angular sand; the entire mass colored and in places cemented with oxide of iron into a massive ferruginous conglomerate sandstone. Intermingled throughout are found numerous silicified fragments of most of the Paleozoic fossils to be found in the Ohio Valley, indicating the origin of this most interesting deposit.

Underneath the gravel bed, there is in many places a pure white sand, marking the division between the Quaternary and Tertiary groups in Western Kentucky.

In descending order are several strata of clay (Eocene Tertiary), both plastic and non-plastic, suitable for pottery, fire-brick, &c. These will be described at length in the Economic Reports of the Geological Survey. The lower portion of the bluff, and the slope on which the lower town is situated, is composed of a plastic clay of greenish-grey color, crumbling when dry into small lumps.†

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* The following is an analysis of an averaged sample taken by me from the bluff at Hickman, by Dr. Robert Peter, Chemist of the Geological Survey:

Silica	68.860
Alumina	12.980
Lime	9.687
Iron oxide	2.240
Magnesia	1.182
Potash	1.773
Soda	1 278
Combined water	2.000
	100.000

† The following is the analysis by Dr. Peter from averaged sample. Clay burns a bright buff color, quite hard. Before the blow-pipe quite refractory:

Silica	77.960
Alumina	13.970
Iron oxide	2.390
Lime	.134
Magnesia	.163
Potash	.797
Soda	.124
Combined water and loss	4.462
	100.000

When wet, this clay, near the surface of the ground, is tramped into an impervious mass, and in this way the natural seeping of water into the earth is prevented, and the evil effects from lack of surface drainage, caused by the elevation of the streets, are aggravated.

With this general description of the town and its surroundings, we enter for a more careful inspection the business portion under the bluff, where the fever first made its appearance. On ascending the bank from he steamboat landing to the railway depot (Lot 234, Map ; 1, Plate I), we see an open flat square (2, Plate I), extending from Market to Water street, several feet lower than the surrounding streets. The impervious condition of the soil, and the absence of any drainage under the streets, prevents the escape of water falling here, and we are told that here there is in the early spring quite a swamp or pond, which remains until the hot summer's sun dries up the water, and exposes the decayed vegetation beneath it. Under the large building and the platform surrounding it (1, Plate I) the water remains during the entire year, as the sun has no access to it.

Passing up Kentucky street into the town, we notice that the portion of the town to the left is also very flat, and that, in most of the open lots, conditions similiar to those just described prevail. We remark the cleanly streets and sidewalks and gutters ; but on turning westward, on Clinton street, and entering the business houses on the south side of the street, we notice that the back portion of them is dark, owing to the fact that Jackson street is about ten feet higher than Clinton, and many of the business houses extend through to the former street. The walls of most of these are built immediately against the earth ; and as they are of ordinary brick, and no hydraulic lime used in their construction, the dampness has penetrated through, in many instances rotting off the plastering, and discoloring it for several feet above the level of the street. Few of these houses are provided with cellars, and as the floors are placed near the ground, with no provision for a free circulation of air under them, the floor timbers soon decay, and require renewing every few years. I saw one floor of yellow pine, put down not longer than twelve months, showing evidences of advanced decay. Where the houses do not extend through to Jackson street, small yards have been excavated back to the sidewalk on a level with the lower floors, and in these yards are the privies for the use of the occupants of the stores and dwellings, and in some instances cisterns from which water is used for drinking and culinary purposes. We can see no drains from these yards or from under the houses. These conditions prevail from Kentucky to

Union street. Our chief business is with the square bounded by Jackson, Kentucky, Carroll, and Cumberland streets, for here were the first cases of yellow fever.

The one story frame building (G, Plate I) was the residence of Mr. Hendricks, and it was here that Charlie Hendricks was attacked with fever on August 12th, and his sister Louisa on the following day. Owing to the natural slope of the ground, the lower side of the house is about six feet above the ground, and the upper side rests on the ground, the earth being eighteen inches higher than the porch floor. The sanitary condition of this house is better than other houses on this square, and in the lower part of the town. It is well drained, and during the month of August the surroundings were dry and reasonably clean. The privy (H, Plate I) is several feet above the level of the floor of this house, and we can see no reason why the washings from the same should not be carried by hard rains under the floors of the rear portion of the house. South of H is another privy about five feet higher; to neither of these is there a vault. The dotted line (references are all to Plate I), extending from the Hendricks house to Kentucky street, is an embankment of about five feet high, between which and Jackson street the ground is perfectly flat. The slope from the top of this embankment to Carroll street may be seen in section accompanying Plate I. The two privies (F) at the northeast corner of the Hendricks house have no pits, and we see the excrement is heaped up for two feet or more above the top of the ground. The tank (31) at the back of the cooper-shop, used for soaking hoops, is filled with foul water. The square plank building (E) is a stable, and was used as such during the summer of 1878; the drippings from the roof running in on the floor, so that it was never very dry At (29), between the two frame houses, there is a space of about twelve inches, into which leaves and some garbage has drifted. The drippings from the roof—there being no gutters—fall into this space, and the studding and weatherboards of both houses are damp and rotten for eighteen inches above the ground. The floors of some of these houses have sunken below the level of the ground, and there is nothing to prevent the wash from the yards running on to them. This is notably the case with the floor of the house at (15). There is a cistern (28) from which I took water analysis. (See Appendix A)

The privy at (27) is the only one noted on this square with a vault. This is filled with excrement to the top; and there being no drain from it, I am informed that sometimes, during very hard rains, the contents

of this vault is floated out of its resting place. The old stable shed at (14) has a floor of planks resting on the earth, which floor is rotten and foul. The cistern (26) is filled with water so impure that it has not been used for some time. The cistern at (25) is used for drinking and household purposes. Around this is a chosen place for the casting of slops. The back portion of the building (13) has sunken several inches into the ground, and the washings must necessarily be carried by rains upon the floor of one of the rooms. The privy (23) is heaped up several feet above the ground, and also another (24) on the upper terrace. The cisterns (21 and 22) are very much used for drinking water. The yard around receives the drainage from the upper portion of the lot. I noticed, also, that the negro women engaged in washing clothes empty the dirty slops around and within a few feet of the cisterns. These waters were sampled for analyses.* The earth on this square is perfectly saturated with organic matter. Under the large frame house (Lot 15, Map; 13, Plate I), known as the City Hotel, used as a tenement house by negroes, there is an excavation of several feet in depth, from which there is no drain. Consequently it is nearly filled with the washings from the lot, and such garbage as the occupants may choose to cast out of sight. Water stands in this place the entire year. During the hot months of summer this becomes a favorite resort for the city hogs; and I am informed that, upon emerging, they were redolent with the perfumes of this cool retreat. Upon taking some of the contents from this pit in November, I found that the frosts, and a large quantity of lime which had been thrown into it, had not altogether deprived it of an offensive odor. These conditions were probably aggravated by the intense heat of the summer of 1878.† I cannot find that there had been any unusual amount of malarial or other fevers previous to August.

*For analyses of these cistern waters, and interesting notes by Dr. Peter on Contamination of Waters, see Appendix A.

†Statement showing the *mean temperature* for the months of June, July, August, September, and October at Cairo, Illinois, and Memphis, Tennessee, compiled from the records on file at the Office of the Chief Signal Officer, Washington, D. C :

DATE—1878.	MEAN TEMPERATURE.	
	Cairo.	Memphis.
June	76.4	73.9
July	83.7	82.7
August	82.1	81.2
September	72.0	70.6
October	61.3	59 0

From the above the mean monthly temperature at Hickman can be approximately arrived at. It will be observed, by comparison with other years, that this was a summer of almost unprecedented heat.

The town authorities, alarmed at the northward spread of yellow fever, had established a quarantine, but the enforcement of it had been neglected or it had been withdrawn, and steamboats from the infected district were allowed to land.

On August 3d the steamer Golden Crown landed at the public wharf, and put off a carriage inclosed in a wooden box. On July 27th* the John D. Porter came near shore, opposite Obion street, to take in tow a barge. At the time the *wind was blowing hard against the shore*, so that the boat could not run to shore with safety, and one end of the barge was swung out into the stream until it could be grappled by the boat. Whilst this was occurring a yawl containing three men pulled up from the boat to the wharf. The men leaving the boat went up to the telegraph office, and it is asserted that two of them went to Mangel's bakery (Lot No 5, Map; 20, Plate I. See also Nos. 7, 8, and 9, tabulated statement of cases). On returning to the wharf, the men waited some minutes on the wharf-boat for the Porter to come up, when they pulled out to the boat and were taken on board. This would indicate that the Porter remained for twenty or thirty minutes in front of the town.

The steamer Golden Rule landed at the wharf-boat August 16th and discharged some freight, then dropped to the lower landing, below Obion street, to coal, where she was detained long enough to allow many of the passengers to go on shore and stroll about the town. No one from Hickman went on board of the John D. Porter. The children, Charlie and Louisa Hendricks, peddled apples on steamboats landing at Hickman, and about the wharf-boat. It is asserted by Mr. Hendricks, their father, that they went on board the steamers Golden Crown and Golden Rule.† The history of yellow fever on the ill-fated John D. Porter is well known. Yellow fever developed on the Golden Rule as early as August 18th, possibly earlier. Six cases were admitted from this boat in the Cincinnati Hospital, two of which died.‡

In the John D. Porter and Golden Rule we have two possible means by which the yellow fever may have been conveyed to Hickman. On August 12th, the first case of yellow fever (Charlie Hendricks) occurred,

* The evidence collected in Hickman from Mr. Overton, the wharfmaster and others, August 5th, was given as the date of the arrival of the Porter I am certain they were mistaken either in the boat or in the date. I have been at some pains to collect the facts respecting the Porter, which I give in Appendix B, where also will be found some important facts connected with the Golden Crown and Golden Rule and other boats from New Orleans. Mr. Overton and others were also of the opinion that the Golden Rule landed August 10. This could not be the date, as the boat left New Orleans on August 10, and arrived at Cairo at 4 P. M., August 16.

†Evidently he was mistaken about the names of the boats.

‡ For history of these cases, see Dr. Minor's report on "The Yellow Fever in Ohio," pp. 45–'6–'7.

followed by his sister Louisa. There was a lull, and no other cases appeared until August 20th. (No. 55.*)

On August 24th 3 new cases (Nos. 71, 121, 196).

On August 25th 5 new cases (Nos. 8, 10, 44, 135, 237).

On August 26th, 2 new cases (Nos. 37, 42).

On August 27th, 6 new cases (Nos. 11, 38, 51, 52, 56, 122).

On August 28th, 9 new cases (Nos. 3, 16, 19, 20, 36, 41, 68, 149, 189).

On August 29th, 8 new cases (Nos. 18, 21, 28, 30, 35, 39, 59, 64).

On August 30th, 4 new cases (Nos. 9, 53, 57, 65).

On August 31st, 5 new cases (Nos. 43, 54, 55, 58, 62).

Some of the young men of Hickman had organized a brass band, and they were in the habit of practicing at a room in the old City Hotel property. (Lot 31, Map; 13, Plate I.) It is worthy of note, that of the six members of this band five were attacked with yellow fever between August 27th and 29th. I was informed by a member of this band that many children of the town were in the habit of standing around this house at night listening to the music. Among the number he remembers the Hendricks children, and Joe Baltzer and Jimmie Young. It will be noticed that the two latter were attacked also August 29th. (See Nos. 29 and 33.)

I have, in the following tabulated statement, given only the cases occurring among the whites. As fewer of the negroes left the town and most of them resided in the lower part, it is believed there were as many cases of fever among them; but the difficulty of obtaining reliable information precluded the statement of cases. It is noteworthy the small percentage of deaths among the negroes. It is thought by those in Hickman best informed on the subject, that there were as many yellow fever cases among the negroes as among the whites; yet there were only eighteen deaths. I have in the following tables a report of 262 cases among the whites. Assuming the same number among the negroes, the deaths would be a little over 7 per cent., whilst 50 per cent. of the whites died.

In preparing the following tables, several cases reported as yellow fever have been excluded, because doubts as to the nature of the disease were expressed by persons best acquainted with the circumstances.

This statement of cases is necessarily imperfect, owing to the fact that no record was kept of fever cases. All of the resident physicians died

* Numbers refer to first column tabulated statement of cases, pp. 76 to 85.

but one (Dr. A. A. Faris), and he had the fever. It has, therefore, been difficult to get much information wanted to make complete a statement of this kind.

I have been greatly assisted in this by Hon. Henry A Tyler, who was in Hickman daily during the epidemic, and by F. E. Case, who kept a record of deaths.

The arrangement which I have adopted in the following tables, it is thought, will best enable persons to study the spread of the disease with reference to the map accompanying this Report. It must be borne in mind that the lots are wide enough to often contain more than one house; so that where two families are located on the same lot, it is not to be inferred that they occupy the same house. In the tables the families are grouped together as much as possible.

The following table, compiled from authentic sources, will give percentage of deaths, from which comparison can be made:

	Cases.			Deaths.			Percentage of deaths—Whites.	Percentage of deaths—Colored.	Percentage of deaths—Total.
	White.	Colored.	Total.	White.	Colored.	Total.			
New Orleans.	14,008*	1,710*	18,576	3,863	183	4,046	27.5	10.	21.8
Vicksburg	3,500†	3,000†	6,500	721	267	988	20.6	8.9	15.2
Memphis	6,000‡	9,000‡	14,000	4,000‡	1,130‡	5,130	66.6	12.5	36.6
Grenada and vicinity .	1,092	400	1,492	368	39	407	33.6	9.7	27.4
Jackson, Miss.	173	317	490	49	35	84	28.3	10.	17.2
Hickman, Ky. . . .	262	200⁒	149	131	18	149	50.	9.	32.2

* Whole number of cases classified; thought by some there were as many as 23,000 cases.

† Estimated.

‡ About: the death list is from names published by the Howard Association.

⁒ Estimated.

The following abbreviations have been used in the tables: E. H., East Hickman; B. A. Balder's Addition, East Hickman; G. A. Golder's Addition, East Hickman; V. L., Vicinity Lot, East Hickman; W. H., West Hickman.

TABULATED STATEMENT OF YELLOW FEVER CASES AT HICKMAN, KENTUCKY.

No.	NAME.	Age.	Residence, No. of Lot.	Place of Business No. of Lot.	Date of Attack by Fever.	Date of Death.	REMARKS.
1	Hendricks, Charlie. .	13	44	. . . . .	Aug. 12 . .	Aug. 16 . .	It is supposed that the Hendricks children peddled apples on the Golden Crown and Golden Rule. They were not on board the John D. Porter.
2	Hendricks, Louisa . .	6	41	. . . . .	Aug. 13(?) .	Aug 17.	
3	Hendricks, Mrs. . . .	45	44	. . . . .	Aug. 28 . .	Sep. 3.	
4	Hendricks, Annie . .	10	44	. . . . .	Sep 1 . .	Sep 6.	
5	Hendricks, John . . .	17	44	. . . . .	Sep 14 . .	Sep 20.	
6	Hendricks, Mr. . . .	50	44	. . . . .	Sep. 18 . .	Recovered	Two small children escaped attack. (See Sohm's family, No. 98.)
7	Mangel, Edward. . .	49	5	5	Aug. 24 . .	Aug. 28 . .	(See R. J. Reid's family, No. 105)
8	Mangel, Mrs E	40	5	5	Aug. 25 . .	Sep. 5.	
9	Mangel, George .	15	5	5	Aug. 30 . .	Recovered	
10	Roulhac, Mrs H.. . .	40	42	. . . . .	Aug. 25 . .	Recovered.	
11	Roulhac, George . . .	21	42	29	Sep. 27 . .	Oct 2 . .	MEMBER OF THE BAND.
12	Millet, John	64	42	. . . . .	Sep. 5 . .	Sep. 11 . .	Mrs. John Millet, the only person in house who escaped attack; she had yellow fever in 1832 in New Orleans.
13	Millet, Miss Rose. . .	35	42	. . . . .	Sep. 4 . .	Recovered.	
14	Millet, Marve	28	42	. . . . .	Sep. 6 . .	Recovered	
15	Millet, Melvin	28	42	. . . . .	Sep. 13 . .	Recovered.	
16	Case, F. E.	25	West Hick'n	29	Aug. 28 . .	Recovered.	MEMBER OF THE BAND. Sick at his father's house in West Hickman, where he came in contact with the family. Family escaped attack
17	Holt, R. D.	40	West Hick'n	3	Sep. 13 .	Sep. 16 . .	Also resided in Mr. Case's family; removed to Hospital; came in contact with Case's family.
18	Hancock, W..	27	195	. . . . .	Aug 29 . .	Sep. 2 . .	MEMBER OF THE BAND. See Bondurant family (No. 212), where he resided; family went to vicinity of lot 124 on September 1.
19	Buckner, W. F., jr.. .	20	L. 3 Bi E. H.	. . . . .	Aug. 28 . .	Sep. 3 . .	MEMBER OF THE BAND.
20	Hunzacker, Gustave .	27	17	T. & S. B. S.S	Aug. 28 . .	Recovered.	MEMBER OF THE BAND. Boarded with Seagrist's family.
21	Young, Jimmie. . . .	12	40	. . . . .	Aug. 29 . .	Aug 30 . .	Only one member of family escaped attack—a boy three years old.
22	Young, Mrs. Ab. . . .	36	40	. . . .	Sep. 8 . .	Sep. 13.	
23	Young, Abner	38	40	Porter Ex. Co	Sep. 11 . .	Sep. 16.	
24	Young, Mrs. Nancy. .	60	40	. . . . .	Sep. 5 . .	Sep. 17.	
25	Young, William . . .	16	40	. . . . .	Sep. 12 . .	Recovered.	
26	Young, Johnnie . . .	10	40	. . . . .	Sep. 15 . .	Recovered	See reference to Jimmie Young, page 80.
27	Young, Ellen.	18	40	. . . . .	Sep. 17 . .	Sep. 20.	

28	Baltzer, George. . . .	9	121	. . . . .	Aug. 29 . .	Recovered.	See reference to Geo Baltzer, page 72.
29	Baltzer, Phil.	39	121	. . . . .	Sep. 12 . .	Sep. 17	
30	Seagrist, Mrs. Frank .	29	17	17	Aug. 29 . .	Sep 3 . .	No member of family escaped.
31	Seagrist, Frank. . . .	45	17	17	Sep. 10 . .	Sep. 14.	
32	Seagrist, Otto	3	17	17	Sep. 10 . .	Sep. 13.	
33	Whal, Miss E.	30	17	17	Sep. 13 . .	Sep 17 . .	} Cook and house-maid in Seagrist's family.
34	Eckert, Miss L. . . .	18	17	17	Sep. 13 . .	Sep. 17 .	
35	Davis, Gus.	30	89	. . . . .	Aug. 29 . .	Sep 1 . .	Remainder of family after the deaths fled and escaped attack.
36	Davis, Lula	11	89	. . . . .	Aug. 28 . .	Sep. 3.	
37	Gleeson, Mrs.	36	16	16	Aug 26 . .	Recovered.	
38	Gleeson, Thos. E . . .	50	16	16	Aug 27 . .	Recovered.	
39	Gleeson, Hallie. . . .	2	16	. . . . .	Aug. 29 . .	Sep 3.	
40	Young, W. E	. .	16	. . . . .	Sep. 11 . .	Recovered.	
41	Harness, N P.	41	49	20	Aug 28 . .	Sep 4 . .	Family fled after his death, and escaped attack.
42	Simones, John	44	116	21 or 22	Aug. 26 . .	Sep. 5 . .	Remainder of family fled after his death, and escaped attack
43	Simones, Mary. . . .	15	116	. . . . .	Aug 31 . .	Recovered.	
44	Witting, Mrs. John. .	36	186	186	Aug. 25 . .	Aug 29 . .	Visited the Hendricks children (lot 44) August 17, during sickness and after death of two.
45	Witting, John	54	186	186	Sep. 18	Recovered.	
46	Witting, Henry . . .	2	186	186	Sep. 19 . .	Sep. 22 . .	
47	Witting, Joseph . . .	14	186	186	Sep. 20 . .	Recovered.	
48	Witting, Clara	18	186	186	Sep. 25 . .	Recovered.	
49	Witting, Annie	20	186	186	Sep. 22 . .	Recovered.	
50	Witting, Katie	4	186	186	Sep. 22 . .	Recovered.	
51	Heatherly, Mac. . .	17	West Hick'n	. . . . .	Aug 27 . .	Sep. 1 . .	Fisherman; about the river a great deal; family left after his death, and escaped attack.
52	Puckett, Geo. W. . . .	68	Country . .	. . . . .	Aug. 27 . .	Sep. 5 . .	Seven miles in country; was in Hickman attending court previous to his attack; died in country; family escaped attack
53	Coffee, William. . . .	17	V. L 92 E. H	110	Aug. 30 . .	Sep 3 . .	Family fled after his death, and escaped attack.
54	Funk, F.	28	. . . . .	110	Aug. 31 . .	Sep. 5 . .	Removed with family to suburbs August 28; family fled after his death and escaped.
55	Slaughter, ——. . . .	23	101-2	3	Aug. 31 . .	Recovered.	Boarded at Planters' House (lots Nos 101 and 102), where she was sick. (See No 205.)
56	Bright, David	25	197	5	Aug. 27 . .	Sep. 9 . .	After his attack family where he boarded fled and escaped attack
57	Gibbs, F.	42	2 (suburbs)	. . . . .	Aug. 30 . .	Sep. 3 . .	Carpenter; reported to have repaired the floor in Ed. Mangel's house (see No 7) August 15 to 20; seven in family; two escaped attack.
58	Gibbs, Emily.	9	2 (suburbs)	. . . . .	Aug 31 . .	Recovered.	
59	Gibbs, Minnie	11	2 (suburbs)	. . . . .	Aug. 29 . .	Recovered.	
60	Gibbs, Mrs. F.	30	2 (suburbs)	. . . . .	Sep. 5 . .	Recovered.	
61	Gibbs, Earnest. . . .	1	2 (suburbs)	. . . . .	Sep. 15 . .	Recovered.	

TABULATED STATEMENT OF YELLOW FEVER CASES AT HICKMAN, KENTUCKY—Continued.

No.	NAME.	Age.	Residence, No. of Lot.	Place of Business No. of Lot.	Date of Attack by Fever.	Date of Death.	REMARKS.
62	Gardner, Mattie	10	194		Aug. 31	Recovered.	It is asserted not in lower town previous to attack.
63	Gardner, Mrs. W. H.	32	194		Sep. 1	Sep. 6	Was down in lower town a week before the attack; after her death family fled and escaped attack.
64	Dunovant, George	26	24	4	Aug. 29	Sep. 7	Clerk with R. O. Luttrell. (See No. 228.)
65	Buncho, Miss	16	27	27	Aug. 30	Recovered.	
66	Buncho, Mrs	57	27	27	Sep. 3	Recovered.	
67	Buncho, Andy	64	27	27	Sep. 14	Sep. 19.	
68	Betts, John	14	10		Aug. 28	Recovered.	Peddled apples on boats.
69	Betts (McCane), John.	25	10	10	Sep. 3	Sep. 6	Keeping hotel (Fulton House).
70	Betts, Sallie	9	10	10	Sep. 13	Recovered.	
71	Betts, Mrs.	49	10	10	Sep. 14	Recovered.	
72	Betts George	11	10		Sep. 14	Recovered.	
73	Ray, Nelson M.		10		Sep. 7	Recovered.	[death, and escaped.
74	Kingman, A. D., jr.	20	62	68	Sep. 1	Sep. 6	Had been nursing the sick; family fled after his
75	Myer, Stephen	29	192 W. H	Drayman	Sep. 2	Sep. 8	After his death family fled and escaped.
76	Barnes, Mrs. J. D.	25	88		Sep. 4	Recovered.	An only child of Mrs. Barnes escaped attack.
77	Barnes, J. D.	31	88	4	Sep 8	Sep. 14.	
78	Barnes, William	40	Country		Sep. 10	Sep. 15	Was in town shortly before attack.
79	Samse, Augusta	17	178		Sep. 1	Recovered.	
80	Samse, Herman	9	178		Sep 5	Recovered.	
81	Samse, Henry	19	178		Sep. 9	Sep. 14.	
82	Samse, Fritz	49	178	Undertaker.	Sep. 9	Sep. 16.	
83	Samse, Charlie	13	178		Sep 13	Sep. 17.	
84	Samse, Ida	4	178		Sep. 29	Oct. 2.	
85	Samse, William	7	178		Sep. 30	Recovered.	
86	Samse Mrs Fritz	33	178		Oc. 4	Oct. 10.	
87	Frick, Mrs. Louisa	73	178		Sep. 22	Recovered.	
88	Nugg, Annie	17	178		Sep. 5	Recovered.	
89	Miller, Mrs Frank	40	47		Sep. 4	Sep. 9.	
90	Miller, Frank	45	47		Sep. 11	Sep. 16.	
91	Miller, Joseph	50	47		Sep. 18	Sep. 22.	
92	Miller, Fenia	18	47		Sep. 1	Recovered.	
93	Miller, Clara	16	47		Sep. 6	Recovered.	
94	Miller, Frank	10	47		Sep. 20	Recovered.	

95	Ashworth, Ben. . . .	21	247 W. H.	6	Sep. 6 . .	Sep. 11.	
96	Hackett, Mrs C . . .	26	247 W H.	. . . . .	Sep. 10 . .	Recovered	Had not been in town during epidemic.
97	Hackett, Charles. . .	26	247 W. H.	Chief Police	Oct. 1 . .	Recovered	Assisted in nursing the sick; two children in same house escaped attack.
98	Sohm, Miss E	19	2 (suburbs)	. . . . .	Sep. 7 . .	Sep. 12 . .	Was in lower town before attacked.
99	Sohm, Willie.	7	2 (suburbs)	. . . . .	Sep. 7 . .	Sep. 14 . .	Was in lower town before attacked.
100	Sohm, Louisa	13	2 (suburbs)	. . . . .	Sep. 9 . .	Recovered.	States she was not in lower town previous to attack.
101	Sohm, Casper	55	2 (suburbs)	10	Sep. 11	Sep. 13 .	Had not been in lower town since August 17
102	Sohm, Mrs. Casper. .	52	2 (suburbs)	. . . . .	Sep. 11 . .	Recovered	Had not been in lower town since August 17.
103	Sohm, John	5	2 (suburbs)	. . . . .	Oct. 5 . .	Oct. 14 . .	Was in lower town before attack. [On September 4 a little daughter of Mrs. Hendricks (See No. 3) was taken to Casper Sohm's for protection, and remained in Sohm's family. This child escaped attack.]
104	Fortune, B. W.. . .	33	Com'l Hotel	R. R. Depot	Sep. 7 . .	Sep 11 . .	Removed after attack to residence of Dr. A. A. Farris.
105	Reid, Mrs R. J . . .	24	5	. . . . .	Sep. 7 . .	Recovered.	Reid and family left early after the attack of Mangel (family occupied the second floor of Mangel s house) for Nashville, where they had the fever and child died.
106	Reid, R J.	34	5	. . . . .	Sep. 9 . .	Recovered.	
107	Reid, R. J., jr. . . .	3	5	. . . . .	Sep 13 . .	Sep. 16.	
108	Blanton Dr. C. . . .	50	360	Attend'g sick	Sep. 8 . .	Sep 13 . .	Family left September 3d, and escaped attack.
109	Amberg, Joseph . . .	59	85	2	Sep. 3 . .	Sep 25.	
110	Amberg, Irene	30	85	. . . . .	Sep. 10 . .	Sep. 14 . .	Mrs Amberg and son left for Cincinnati the day after Mr Amberg's death; son escaped; Mrs A. had fever in Cincinnati; see Dr Minor s report, page 75.
111	Amberg. Vickie . . .	23	85	. . . . .	Sep. 18 . .	Sep. 25.	
112	Amberg, Mrs. J. . . .	56	85	. . . . .	Sep. 30 . .	Recovered.	
113	Frenz, William. . . .	31	85	. . . . .	Sep. 15 . .	Sep. 21.	
114	Catlett, Dr. H C. . .	67	305 W. H.	Attend'g sick	Sep. 11 . .	Sep. 16 . .	Family left after his death and escaped attack.
115	Hertwick, Mattie. . .	11	120	. . . . .	Sep. 11 . .	Recovered.	
116	Hertwick, Ed.	6	120	. . . . .	Sep. 11 . .	Recovered.	
117	Hertwick, John . . .	3	120	. . . . .	Sep. 11 . .	Recovered.	
118	Hertwick, Max. . .	9	120	. . . . .	Sep. 12 . .	Recovered.	
119	Hertwick, Mrs. M. . .	31	120	. . . . .	Sep. 12 . .	? ?	
120	Hertwick, Max. . . .	42	120	13	Sep. 14 . .	Sep. 18 . .	A son 2 years old escaped attack.
121	Person, Mr.	45	223	. . . . .	Aug. 24 . .	Recovered.	Mrs. Person had bilious fever as early as August 8, and escaped attack.
122	Person, Louis	19	223	. . . . .	Aug. 27 . .	Recovered.	
123	Person, Harry	10	223	. . . . .	Sep. 18 . .	Recovered.	
124	Person, Louisa. . . .	6	223	. . . . .	Sep. 22 . .	Sep. 27.	
125	Halyburton, Mrs Cora	24	162	. . . . .	Sep. 1 . .	Sep. 15 . .	Went with husband and son to Louisville, where she and son died; husband escaped attack.
126	Halyburton, infant son	2 m	162	. . . . .	Sep. 1 . .	Sep. 15.	
127	Nelson, N. L.	51	103	103	Sep. 11 . .	Sep. 14.	

TABULATED STATEMENT OF YELLOW FEVER CASES AT HICKMAN, KENTUCKY—Continued.

No.	NAME.	Age.	Residence, No. of Lot.	Place of Business No. of Lot.	Date of Attack by Fever.	Date of Death.	REMARKS.
128	Nelson, Mrs N. L. . .	33	103	103	Sep. 7 . .	Sep. 15.	
129	Nelson Mattie	4	103	. . . . .	Sep. 11 . .	Recovered.	One child escaped attack.
130	Stoner, Mrs. Fred. . .	17	10	94	Sep. 5 . .	Recovered.	
131	Stoner, Fred. . . .	25	10	13	Sep. 14 . .	Sep. 16.	
132	Kesterson, E. H. . . .	34	94	94	Oct. 5 . .	Oct. 10 . .	Confined in jail (lot 94).
133	Stoner, Mrs Kate . .	70	94	94	Oct. 5 . .	Oct. 11.	
134	Smith, O P.	48	8, 9, 10, W H		Sep 11 . .	Sep. 15 .	In town frequently before attack.
135	Smith, Kate		8, 9, 10, W H		Aug. 25 . .	Recovered.	One son escaped attack
136	Smith, Ed.		8, 9, 10 W H		Oct. 1 . .	Recovered.	
137	Smith, Mrs O. P. . . .		8, 9, 10, W. H.		Oct 13 . .	Recovered.	
138	Bayless, Edgar	16	195 & 124 E H.		Sep. 10 . .	Sep. 15 . .	See Bondurant family, No. 216.
139	Perham, W T.	3	Country. .	. .	Sep. 13 . .	Sep 15.	
140	Dozier, T. C.	38	194	Nursing sick	Sep. 12 . .	Sep 10 . .	No family (see Nos. 51, 52).
141	Brevard, W. A. . . .	49	366	. . . . .	Sep. 10 . .	Sep 16 . .	At beginning of epidemic took family to Dr. Alexander's; he returned to Hickman during the day; family escaped attack. (See Dr. Alexander, No 245.)
142	Prather, Dr R C. . .	27	188	Attend'g sick	Sep. 12 . .	Sep. 18 . .	Family sent to country September 19, and escaped.
143	Prather Dr. H L. . .	23	188	Attend'g sick	Sep 21 . .	Sep. 27 . .	Returned to his home in Missouri after death of his brother (Dr. R. C P.), where he died.
144	Prather, Mrs R. C. . .	22	188	. . . . .	Sep. 23 . .	Recovered.	Mrs. P. returned to Hickman during the day to visit her husband; had fever in country; family in country escaped attack.
145	Scharfe, Mrs E. . . .	36	24	. . . . .	Sep 12 . .	Recovered.	Removed to Dr. Catlett's residence, 305 West Hickman, on September 23, where they remained during illness.
146	Scharfe, Ida	13	24	. . . . .	Sep 20 . .	Recovered.	
147	Schafer I	71	24	. . . . .	Sep. 29	Recovered.	
148	Scharfe, E	42	24	24	Sep. 20 . .	Sep. 23.	
149	Jones, Mrs. T. M . .	30	255 B. 2 E. H	. . . .	Aug 28 . .	Recovered.	Had been to town previous to attack.
150	Jones, T. M.	37	255 B 2 E. H.		Sep 16 . .	Sep. 22 . .	Had been to town every day previous to attack.
151	Parker, Alice.	24	255 B. 2 E. H.		Sep. 28 . .	Recovered.	Had not been to town previous to September 25, on which date she went to town and took the train for Nashville
152	Freedle, George . .	35	Nurse in hospital		Oct. 8 . .	Recovered.	When attacked, removed to lot No. 219, West Hickman.

153	May Mrs. James . . .	28	38	. . . . .	Sep. 8 . .	Recovered.
154	May. James	38	38	. . . . .	Sep. 10 . .	Recovered.
155	May)	10	38	. . . . .	Sep. 11 . .	Recovered.
156	May } children	6	38	. . . . .	Sep. 12 . .	Recovered.
157	May)	2	38	. . . . .	Sep. 13 . .	Recovered.
158	Stover, Thos	22	Express messenger at R R.		Sep. 10 . .	Recovered.
159	Berger, Herman . . .	20	204 W H.	. . . . .	Sep 11 . .	Sep. 18 . .	Had been to Hickman previous to attack.
160	Berger, J. G.	60	204 W. H.	. . . . .	Sep 25 . .	Oct. 1 . .	Had been to Hickman previous to attack.
161	Berger, Mrs J. G. . .	54	204 W. H.	. . . . .	Oct. 1 . .	Oct. 10 . .	Had not been to Hickman previous to attack. No others in the family.
162	Rose, Laura	16	91	. . . . .	Sep. 9 . .	Recovered.	Removed to country September 6; had been in Lower Hickman August 26; family in country escaped attack.
163	Shoemaker, John. . .	47	Attending sick at hospital		Sep. 13 . .	Sep. 17.	
164	Thomas, Gus	16	223 W. H.	. . . . .	Sep. 10 . .	Recovered	Was in town daily previous to attack.
165	Thomas, Jas C. . . .	24	223 W. H.	5	Sep. 15 . .	Sep. 20 . .	Four children were taken to the country (from 223 West Hickman) after J. C J. was attacked, and escaped attack; these children had come in contact with other cases of yellow fever before going to country.
166	Thomas, Thad. W. . .	45	223 W. H.	. . . . .	Oct. 1 . .	Oct. 2 . .	Member of the Relief Committee; was in town previous to attack
167	Thomas, Sallie	19	223 W. H.	. . . . .	Oct. 13 . .	Oct. 18 . .	} Were not in town previous to attack.
168	Thomas. Mrs. Mary. .	42	223 W. H.	. . . . .	Oct. 19 . .	Oct 24 . .	
169	Karher, Charles . . .	38	On the hill.	. . . . .	Sep. 14 . .	. .	Was in town daily previous to attack
170	Karher, Mary	2 m	On the hill.	. . . . .	Sep 10 . .	Sep. 24.	
171	Karher. Josephine . .	2 m	On the hill.	. . . . .	Sep. 25 . .	Sep. 24.	
172	Karher Eva.	38	On the hill.	. . . . .	Sep. 25 . .	Oct. 9.	
173	Karher, Henry	14	On the hill.	. . . . .	Sep 22 . .	Recovered.	Was in town daily previous to attack.
174	Karher, Frank	. .	On the hill.	. . . . .	Sep. 28	Recovered.	
175	Karher, Annie. . . .	. .	On the hill.	. . . . .	Sep. 28 . .	Recovered.	
176	Neal, Mrs M.	35	67	. . . . .	Sep. 15 . .	Recovered.	Had both been in lower town several times between 1st and 10th of September; no others in the family.
177	Neal, M.	50	67	. . . . .	Sep. 16 . .	Sep. 21	
178	Dill, Annie	27	150	. . . . .	Sep. 5 . .	Recovered.	Was in lower part of town September 3d and 4th, and previously.
179	Henderson, Emma . .	17	150	. . . . .	Sep. 18 . .	Recovered.	Was in lower part of town September 3d and 4th.
180	Lacy, Miss.	33	150	. . . . .	Sep. 19 . .	Recovered.	None of the other members of the family had been to lower town, it is stated, for some time previous to attack.
181	Lacy, Susan	28	150	. . . . .	Sep. 18 . .	Recovered.	
182	Lacy, Mrs.	68	150	. . . . .	Sep. 18 . .	Sep. 23.	

TABULATED STATEMENT OF YELLOW FEVER CASES AT HICKMAN, KENTUCKY—Continued.

No.	NAME.	Age.	Residence, No. of Lot.	Place of Business No. of Lot.	Date of Attack by Fever.	Date of Death.	REMARKS.
183	Boudinot, Mrs	60	121	. . . . .	Sep. 14 . .	Recovered.	A daughter aged 30, who had bilious fever August 1, escaped attack.
184	Boudinot, William . .	25	121	. . . . .	Sep. 13 . .	Recovered.	
185	Boudinot, Alice .	22	121	. . . . .	Sep, 14 . .	Recovered.	
186	Wilson, Mrs F. . . .	51	362	. . . . .	Sep. 18 . .	Recovered.	Mrs. W had not been from home during the epidemic.
187	Wilson Charles . . .	19	362	. . . . .	Sep. 21 . .	Recovered.	Had been down in town previous to attack; son and
188	Wilson, Jennie	20	362	. . . . .	Sep. 19 . .	Recovered.	daughter in lower town previous to attack; daughter after September 1; don't remember date; no others in family.
189	Metheny, Minnie . . .	11	77	. . . . .	Aug 28 . .	Recovered,	Robert Metheny removed family to country Septem-
190	Metheny, Robert, jr. .	6 w	77	. . . . .	. . . . .	Sep. 26.	ber 5; he went into Hickman frequently; returned
191	Metheny, Robert. . .	40	77	. . . . .	Nov. 5 . .	Recovered.	with family to his residence October 22; Minnie had been in lower town previous to attack; eight in family; others escaped attack.
192	Vanderver, Mrs . .	44	77	. . . . .	Oct 31 . .	Nov. 3 . .	Mrs. V. did not go to lower town after return.
193	McConnel, James . .	31	Country . .	. . . . .	Sep. 20 .	Sep. 26 . .	Went into Hickman during the day with supplies; died in the country; family escaped attack
194	O'Neal, Michael . . .	22	Nurse in hos'l	. . . . .	Sep. 19 . .	Sep. 25 . .	No family in Hickman
195	Faris Dr. Jas. W. . . .	30	Att'g the sick	. . . . .	Sep 21 . .	Sep. 27 . .	When attacked went to Dr. Alexander's where he died (see No. 127); removed family to Dr. Alexander's about September 22.
196	Mason, Mrs	53	E. H.	. . . . .	Aug. 24 . .	Recovered.	Mrs. Mason went to lower town (remained during the day, lot 103) August 19.
197	Mason, James	21	E. H	. . . . .	Sep. 17 . .	Recovered.	Jas. Mason went into town daily previous to attack.
198	Mason, Charlie	15	E. H.	. . . . .	Sep. 18 . .	Sep. 30 . .	Went to town previous to his attack.
199	Mason, Noah	11	E. H.	. . . . .	Oct. 3 . .	Recovered,	It is asserted that Noah Mason did not go to Hickman at all during the epidemic.
200	Monroe, Louis. . . .	26	W. H.	. . . . .	Sep 13 . .	Sep 17 . .	Sent family to country early before he was attacked; they escaped attack.
201	Kestners, Louis . .	30	85 W. H.	. . . . .	Sep. 21 . .	Recovered.	Assisted undertaker.
202	Kestners Regina . . .	59	85 W. H	. . . . .	Sep. 30 . .	Recovered.	Had not been in town during epidemic; went to
203	Kestners, Addie . . .	14	85 W. H.	. . . . .	Oct 20 . .	Recovered.	country about September 1; returned September 30. and was attacked same night
204	Kestners, Marcus . . .	56	85 W. H.	. . . . .	Oct 19 . .	Nov. 8 . .	Was in town daily previous to attack,

205	Lane, Life.	6	101 (Planter's	House)	101	Sep. 23 . .	Recovered.	Mrs Lane was attacked with bilious fever about
206	Lane, T J.	42	101		101	Sep. 26 . .	Oct. 1.	September 17, afterwards with yellow fever Octo-
207	Lane Henry. . . .	4	101		101	Oct 1 . .	Recovered.	ber 7; removed to West Hickman latter part of
208	Lane, Tom.	2	101		101	Oct. 30 . .	Recovered.	October, where youngest son Tom was attacked;
209	Lane, Mrs T J. . .	25	101		101	Oct. 7 . .	Recovered.	several persons living in West Hickman came in
210	Creel, B.	19	101		101	Sep. 24 .	Recovered.	contact with this boy during his illness and es-
211	Overton, Maggie. .	22	101		101	Oct 4 . .	Oct. 8.	caped attack.
212	Sheron, Mrs. Catharine	59	358	. . . .		Sep. 2 . .	Recovered.	They were frequently in the lower town before at-
213	Sheron Joseph . . .	15	358	. . . . .		Oct. 1 . .	Oct. 4.	tacked.
214	Sheron, Tom	18	358	. . . . .		Oct 2 . .	Oct. 6.	
215	Sheron, Miss. . . .	19	358	. . . .		Oct. 6 . .	Recovered.	
216	Bondurant, Jennie . .	3	194 & 124 F. H	. . . .		Sep. 24	Sep. 27 . .	On September 1 family removed to vicinity lot 124;
217	Bondurant Mrs J. J. C	29	194 & 124 E. H	. . . .		Sep. 27	Sep. 30.	Mrs. B. and one child escaped attack; had not
218	Bondurant, Albert G. .	6	194 & 124 E. H.	. . . . .			. . . .	been to town.
219	Cook, Dr. J. L. . . .	. .	118 E. H	Att'g sick (1)		Sep. 26 . .	Oct 1 . .	Volunteer physician from Hender on, Ky.; sick at the residence of H. A. Tyler (Lot 383), where he was visited by his wife from Henderson; she es- caped attack.
220	Buck, T. C.	62	Suburbs. .		1	Sep. 26 . .	Oct. 2	Spent the days in Hickman; remained with family in country. ¾ mile from town, at night, where he died; family escaped attack.
221	Glaser, Robbie . . .	7	253 W. H.	. . . .		Sep 27 . .	Oct. 2 . .	Neither had been to town for 2 or 3 weeks previous
222	Glaser, Joseph. . .	11	253 W. H.	. . . .		Oct. 4 . .	Oct 10.	to attack; father and a brother, who attended them, and who went into town daily for medicines and supplies, escaped attack
223	Prather, Geo. B . .	30	143 W. H		1	Sep 29	Oct. 2 . .	Removed with family to country September 1; went
224	Prather, Mrs. Geo B .	23	143 W. H.	. . . . .		Oct 30 . .	Recovered.	into Hickman several times during the day; died in country; Mrs Prather and child returned to the residence of J. A. Overton, 140 West Hick- man, October 23; child escaped attack. (See Mrs. J. A. O., No. 260.)
225	Corbett, Mrs. W. D .	40	118 E. H.	. . . . .		Oct 2 . .	Oct. 8 . .	Dr. Corbett removed with family to suburbs, where
226	Corbett, Dr. W. D. . .	50	118 E. H.	Att'g the sick		Oct. 5 . .	Oct. 11.	he spent his nights; going to Hickman during
227	Corbett, child	9	118 E. H.	. . . . .		Oct. 8 .	Recovered	the day; returned with family to home (118 East Hickman) about September 25.
228	Luttrell, Effie	20	120 E. H.	. . . . .		Sep. 20 . .	Recovered.	Each member of family, excepting infant child, was
229	Luttrell (infant child).	3 m	120 E. H.	. . . . .		Oct. 2 . .	Oct. 6.	in town every few days previous to attack; Mrs.
230	Luttrell, Fortleigh . .	16	120 E. H.	. . . . .		Oct. 3 . .	Recovered.	Luttrell the only member of family who escaped
231	Luttrell Coppie. . .	18	120 E. H.	. . . . .		Oct 6	Oct 11.	attack, was not in lower town after August 17.
232	Luttrell, J. L.	50	120 E. H.	. . . . .		Oct. 13 . .	Recovered.	

TABULATED STATEMENT OF YELLOW FEVER CASES AT HICKMAN, KENTUCKY—Continued.

No.	NAME.	Age.	Residence, No. of Lot	Place of Business No. of Lot.	Date of Attack by Fever.	Date of Death.	REMARKS.
233	Luttrell, Verona . . .	12	120 E H.	. . . . .	Oct 16 . .	Recovered.	
234	Luttrell, Mary. . . .	2	120 E. H	. . . . .	Oct 23 . .	Recovered.	
235	Cobbs, Charles. . . .	22	16 (Slept on	wharf-boat)	Sep 30 . .	Oct 5 . .	Left at beginning of epidemic; returned Sept. 20.
236	Pollard, E. M. . . .	19	16 (Slept on	wharf-boat)	Sep. 29	Oct. 5 . .	Telegraph operator; came to Hickman Sept. 20.
237	Wilburn George . . .	50	223 W. H	. . . . .	Aug. 25 . .	Recovered.	In Hickman previous to attack; Mrs. Wilburn escaped attack; two others of family escaped attack.
238	Wilburn, Henry . . .	13	223 W. H.	. . . . .	Oct 8 . .	Oct 13 . .	In Hickman previous to attack, about October 4.
239	Wilburn, T. F.	23	223 W. H	. . . .	Oct. 10 . .	Recovered.	In Hickman previous to attack
240	Gober, Dr. D.	51	383	Att'g the sick	Oct. 3 .	Recovered.	Volunteer physician from Louisville.
241	Barry, Mrs. John . . .	40	F. H.(sub'bs)	. . . . .	Oct. 8 . .	Oct. 19 . .	Remainder of family escaped attack; had not been in town for 30 days previous to attack.
242	Hertwick, Otto. . . .	43	151	Undertaker.	Oct 6 . .	Recovered.	Removed family to country early; escaped attack
243	Greenup John . . .	30	Nurse in hos'l	. . . . .	Oct 9	Oct. 13 . .	Nurse from Frankfort; no family in Hickman.
244	Alexander Dr J M. .	61	10 miles in	country. . .	Oct. 12 .	Oct. 18 . .	Dr A. went to town frequently to visit the sick,
245	Alexander, Belle . . .	19	10 miles in	country. . .	Oct. 15 . .	Oct. 30.	and remained with Dr Corbett on the nights of 8th and 10th. Miss Belle went to town with him on October 12, and remained in town two hours; this was her only visit to Hickman during the epidemic.
246	Black, Joseph	20	101 W. H.	. . . . .	Oct 18 .	Oct. 23 . .	Had been in Hickman daily before attack; five in family; all escaped attack except two.
247	Black, Mollie	15	101 W. H	. . . . .	Oct. 1	Recovered.	Had not been in town during epidemic.
248	Faris, Thomas . .	25	101	. . . . .	. . . . .	Oct. 23.	
249	Faris, Dr. A. A. . . .	.	. . . . .	. . . . .	. . . . .	Recovered.	
250	Cole, John	14	W. H	. . . . .	Sep. 24 . .	Recovered.	Went to town daily previous to attack.
251	Cole, Elizabeth. . . .	40	W. H.	. . . . .	Oct. 1 . .	Recovered.	
252	Cole, Lush. . . .	16	W. H.	. . . . .	Oct. 1 . .	Recovered.	Went to town daily precious to attack Chas Cole
253	Cole, Catherine. . . .	8	W H.	. . . . .	Oct. 1 . .	Recovered.	went to town daily and attended the sick at
254	Cole Lotta.	6	W. H	. . . . .	Oct. 19 . .	Oct 25.	home; escaped attack.
255	Ringwood, John .	50	No. 222 W.H.	. . . . .	Oct 5 . .	Recovered	Went to Hickman daily previous to attack; two members of family escaped attack
256	Ringwood, Ellen . . .	16	F. 222 W H	. . . . .	Oct. 5 . .	Recovered.	Had not been in town previous to attack.
257	Anderson, A S . . .	56	V L 122 E. H.	. . . . .	Oct 19 . .	Oct. 23 . .	Mr. Anderson went to lower town every day previ-
258	Anderson, Mrs. . . .	55	V L. 122 E. H	. . . . .	Oct. 22 . .	Recovered.	ous to attack; Mrs. A and daughter did not go
259	Anderson Mollie. . .	19	V. L. 122	. . . . .	Oct. 22 . .	Recovered.	to town.

260	Overton, Mrs. J. A. . .	50	140 W. H.	. . . . .	Nov. 1 . .	Nov. 6 . .	Went to country September 1; returned to home (140 West Hickman) October 27; J. A. Overton remained in Hickman night and day during entire epidemic, sleeping at night on wharf-boat; he escaped attack.
261	McMahan, J. R. . . .	48	Suburbs . .	Suburbs . .	Nov. 3 . .	Recovered.	Quarantined self and family at home half mile in country; after heavy frost October 28 went to town; went into stores just opened where fires had been made in stores for first time since opening.

(1). As there was an opinion prevailing at Hickman, during the summer of '78, that yellow fever was only contracted at night; also, that persons who slept in the upper stories of buildings were less liable to attack, I deem it worthy of note to call attention to several cases seeming to disprove the truth of this theory. Dr. Cook slept in the upper story of the residence (118 E. H.) on the bluff. It will be seen, by reference to the map, that this building has an elevation of 440 feet above sea level. Persons living in the country, Miss Belle Alexander and others, came to Hickman during the day, believing that the risk was small. Miss Alexander's object in going into Hickman was to prevent her father from remaining there over night. The failure of prophylactics will doubtless be referred to in Dr. Thompson's report.

(2). Information of the following cases was received too late for insertion in the tabulated statement: W. D. Taylor, attacked September 27, recovered; he moved family to country early, and wife returned October 14, and was attacked October 18; recovered; children remained in country, and escaped. The following persons remained at Hickman during the epidemic, and escaped attack: James A. Overton, R. Glaser, Charles Cole, John Ringwood, jr., F. Berendes and family. The following came to Hickman frequently and escaped: Jeff. Alexander, M. D. Johnson, H. H. Harding, R. T. Tyler, W. W. Marshall, P. C. Greer, H. C. Bailey. There were several others, whites and negroes, but I have not obtained names. It is supposed by some that Henry A. Tyler had yellow fever; he was attacked about August 27, with what he and the attending physician supposed at the time to be malarial fever. As he was exposed to the yellow fever daily after his recovery, it has been thought that perhaps he had yellow fever. On account of the doubts I have not placed this among the cases in the tabulated statement.

(3). These tables are not presented as complete, but as much so as I have been enabled to make them from the insufficient data obtainable.

An analysis of the foregoing tables gives the following results:

Total number of cases among the whites	262
Total deaths among the whites	131
Percentage of deaths	*50
Deaths in August	5
Deaths in September	87
Deaths in October	36
Deaths in November	3
Total males attacked	147
Total females attacked	115
Total deaths among males	89
Total deaths among females	42
Percentage of deaths to males attacked	60
Percentage of deaths to females attacked	36.5

Out of 94 male adults attacked 70 died—a percentage of 74.4.

A study of the tables, with reference to the map, will show the spread of the fever. It will be observed that all of the persons attacked with fever in West Hickman, previous to September 27, had been east of Obion street previous to attack. As many as seven cases occurred in West Hickman after that date, of persons who had not been east of that street during the epidemic. In this way the approximated date of the spread of the fever upon the bluffs may also be determined.

I have endeavored to give such leading facts as may be most important in aiding others to study and draw conclusions from the epidemic at Hickman. My own knowledge and study of yellow fever is too limited to justify me in putting on record any opinions or conclusions I may have formed.

That the sanitary condition of a portion of the town under the bluff was bad there is no question, and the abstract proposition that bad sanitary conditions exaggerate most epidemic diseases may be true; but there are some facts connected with the history of this visitation of fever at Hickman which render arguments based upon the aggravation of the disease by these conditions somewhat hazardous. The sanitary condition of the Hendricks house and surroundings was no worse, not so bad, as many houses where the fever appeared later, and where it was not so fatal. The only family in Lower Hickman remaining through the epidemic, and escaping attack, was the Berendes family (Lot 22, map). The sanitary conditions of this house and its surroundings were exceptionally bad.

On one street (Carroll), as clean and well drained as could be desired, every man remaining—fifteen in number—had the fever, and eleven died. Every person remaining on this street had the fever excepting Mrs. Millet, who had fever in New Orleans in 1832.

* The death rate at Hickman, though large, was not so great as at some other places. At Memphis it was 66.6 per cent. among the whites; at Stoneville, Mississippi, it amounted to 72 per cent., including negroes.

That the fever did not prove as destructive on the bluff as in the lower town, may be accounted for by the fact that when it became epidemic on the bluff many of the inhabitants had fled; besides, the houses are farther apart, and the population more scattered than in the lower town. The sanitary conditions of Hickman were no worse than I saw, upon examination, in Cairo and Louisville, on my return from Hickman. That those cities escaped, and that the fever did not prove more destructive in the latter place, after its appearance there, must be attributed to other causes than superior cleanliness. It cannot be attributed to greater elevation above sea level. Broadway street, Louisville, at Louisville and Nashville depot, is 432 feet above sea level, and much of the city is below this level. Well authenticated cases occurred in East Hickman at an elevation above sea level of 440 feet.*

But a clean, well drained town ought to be better prepared against the ravages of any epidemic diseases than one lacking these safeguards; and as no town has greater facilities for thorough drainage than Hickman, by the construction of two or more main sewers in the lower town, into which lateral feeders may be conducted from the various squares, and an arrangement by which the water descending from the bluff and sloping streets will pass into and through these sewers, a good system of drainage can be had. Nature has placed within the limits of the town materials from which admirable drain-pipe and sewers may be constructed. Excellent clay, from which drain-tile can be burned, is abundant. But as these can be purchased cheaply, it would hardly repay the outlay to obtain necessary machinery and kilns for burning, unless a permanent manufactory for the sale beyond the limits of the town was intended.

My opinion is, that the cheapest and best material for permanent drains is to be found in the bluff gravel, that being, beyond question, the finest ready-prepared concrete material I have ever seen.† The value of concrete in construction has been attested by the durability of structures erected centuries ago; and late experiments have proved, that where the materials for its construction are cheaply obtained, it is cheaper than stone or brick as a building material.

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* Chattanooga, Tennessee, where there were 693 cases and 197 deaths, must have an average elevation above the sea of 700 feet. The low water mark of Tennessee river at that place is 643 feet above sea level. Chattanooga is *north* of the isothermal (56°) which passes through Frankfort, Louisville and St. Louis.

† The uses of this material as a concrete building material, a street material, &c., will be treated of at length in the Economic Reports of the Geological Survey.

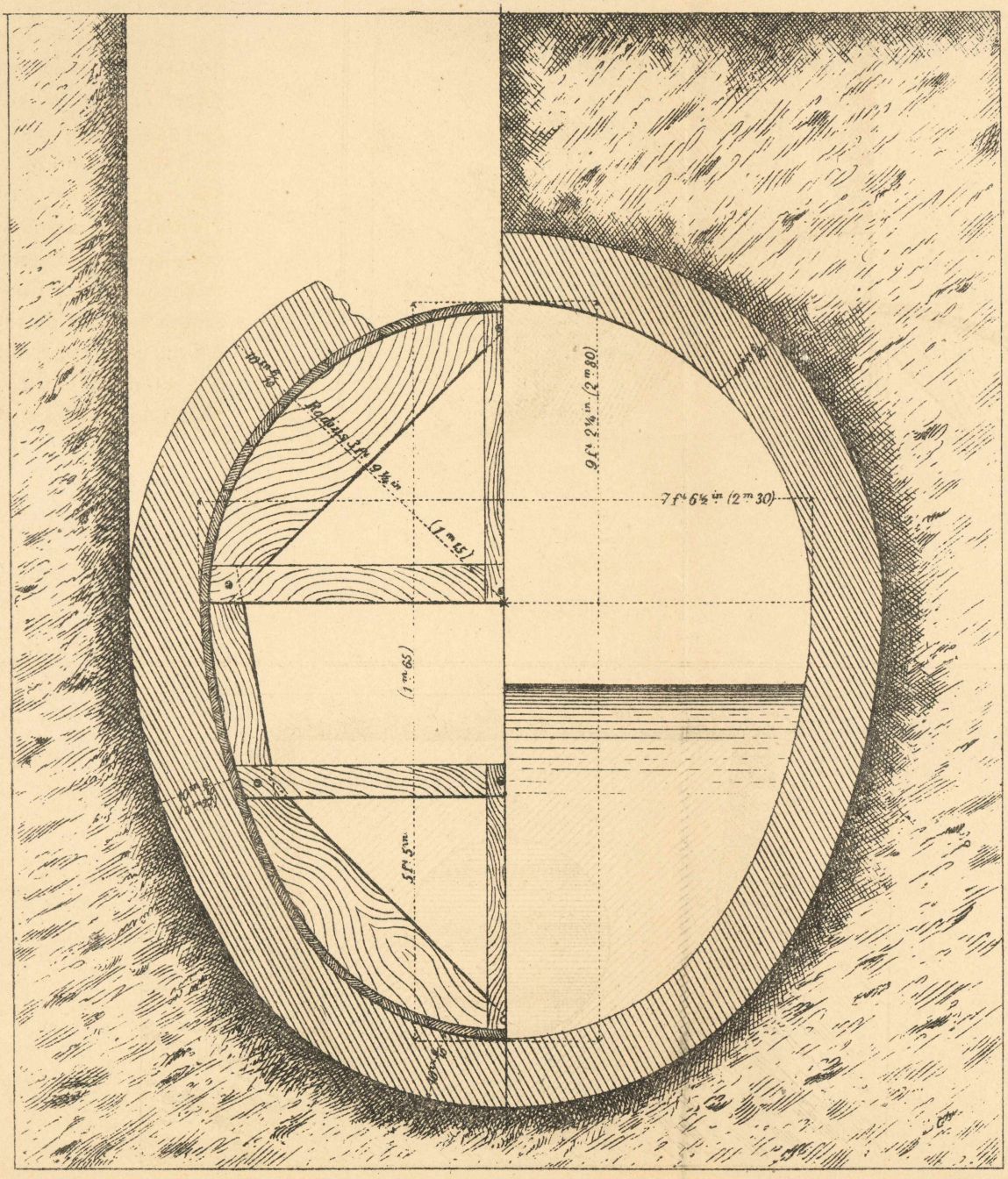
In France it is extensively used, under the name of Béton-Coignet,* in the construction of sewers, water-pipes, foundations, walls, arches, buildings, aqueducts, reservoirs, &c.

In Paris, over forty miles of sewers have been constructed of this material. The foundations, underground arches, drains, &c., both for the Exhibition buildings of 1867 and 1878, were of concrete. I have given a drawing showing the method of construction of one of the branch sewers in the city of Paris (Fig. 1, Plate II), and a smaller water conduit (Fig. 2, Plate II). Although the sewer here figured is larger than any required at Hickman, the method of construction may prove of value. A trench is cut the required size, upon the bottom of which a floor of béton is laid. A framework of timber and boards is introduced, such as would be used in the construction of a sewer of masonry. Around this the béton is dumped and packed by a common laborer. The woodwork is then removed, and the sewer is complete. For smaller sewers, such as would be required at Hickman, a cylinder or core of the requisite shape could be used, around which the concrete could be compacted; after which the core could be drawn along, and the same operation repeated. Terra cotta side drains could be introduced whenever needed for lateral branches. In Paris it is known that building stone is abundant and cheap; yet béton sewers cost 30 per cent. less than stone, and much less for repairs. Water-pipes in Paris are constructed from this material at about one half the cost of iron. A sewer 5 5 feet high, 2.5 feet wide, and 7.8 inches thick, contains 11 cubic feet of concrete per linear foot of sewer. The value of concrete depends on the peculiar qualities of the materials used, and the careful manipulation of the same. The angular shape of the chert pebbles, and the quantity of large sharp sand in the Hickman gravel, render it peculiarly adapted to make a strong and durable structure. Either hydraulic or ordinary fat lime may be used for foundations; but for sewers, the former would be preferable. The gravel should be freed from all pebbles larger than one inch cube, which could be done cheaply by screening; then it should be moistened just sufficiently to cause the lime and cement to adhere. Over the mass the lime should be sifted, whilst the mass was stirred, so that a thin coating of the same would be on the pebbles and sand; the proportion of lime and sand to be determined by the character of the structure required. One part of Louisville cement to seven parts gravel and sand would make a durable and strong sewer.

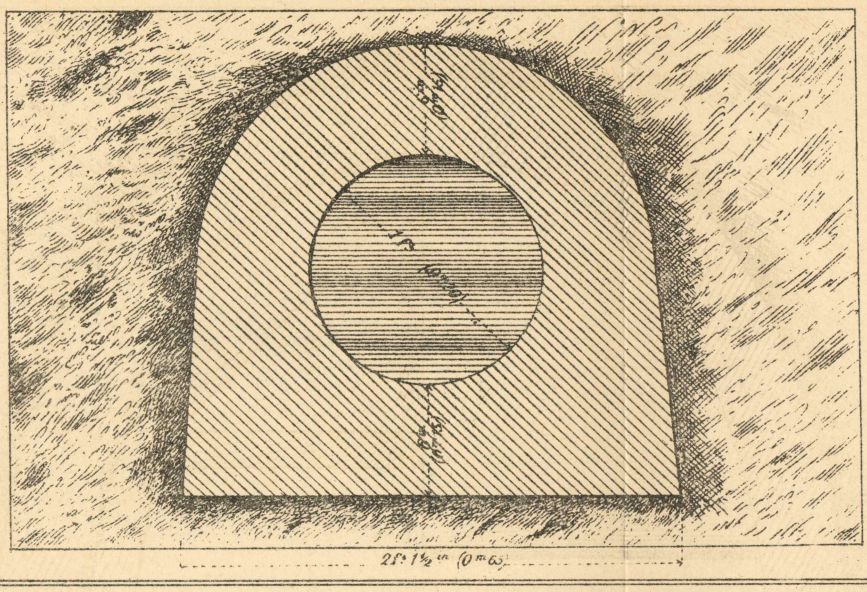
* So named after M. Coignet, the engineer who introduced the use of this material in France.

Construcuon of a Sewer of Béton. City of Paris.

scale 1/25



Water Conduit scale 1/10



I made blocks 3½ inches cube of gravel from Hickman and Paducah, using in the various blocks Louisville cement, Portland cement, and ordinary quick lime. Blocks containing 1 part of Louisville cement to 7 sand and gravel, and blocks with 1 part quicklime to 8 gravel and sand, and ½ of of 1 part of Portland cement, withstood a crushing weight of from 11,000 to 12,000 pounds.* After drainage, I would recommend that areas be excavated back of the stores running through from Clinton to Jackson streets, and along the sides of the buildings between those streets fronting on Cumberland street.

For retaining walls to these areas, concrete from the same gravel can be used. Instead of hydraulic lime, quicklime will answer for these walls, although the former would be preferable. By sloping the bottom of these areas away from the buildings, and putting a drain on the lower side, the buildings will be rendered much dryer. I think it injudicious to use brick-work in foundations, and for all buildings in the future, reliable and dry foundation can be had at much less cost from the gravel. Nearly all the heavy machinery at the Paris Exposition was placed on blocks of concrete. This gravel, when placed in a ditch and pounded, will be compacted mechanically into a hard block, and I believe will be a firm foundation for ordinary buildings without any addition of lime or cement. Of course, that portion of the foundation above the ground should be mixed with lime or cement.

I would also recommend that the present system of closets in the lower town be reorganized. I believe that unless an abundant supply of water and good drainage can be had, the present system of closet on top of ground is preferable to one with a pit, or even to the ordinary water-closet; but care should be taken that the surrounding ground be not contaminated, and that proper absorbents and disinfectants are used, so that the excrement be rendered harmless, and can be removed with ease. I will not recommend any of the earth closets, admirable as some of them are, for they are expensive, and, unless carefully cared for, defeat the objects for which they are designed. With the closets at present in use, inexpensive appliances can be adapted which will render them harmless.

In England simple and inexpensive systems have been adopted, known as the Rochdale "pail closet," and the Manchester "dry ash

* Should the authorities of Hickman, or of any of the towns in Western Kentucky, desire to use this gravel in the construction of sewers, foundations, or other purposes, specifications more in detail will be furnished upon application to the office of the Geological Survey.

closet." The former, which has been in use since 1868, consists of an ordinary out of door closet, such as are in general use throughout this country, beneath the seat of which is placed a pail made from half a kerosene barrel. This pail is capable of holding one hundred pounds; the average weight of its contents, after a week's use by a family of ordinary size, was 41 pounds. In 1871, out of the 13,938 inhabited houses of Rochdale, 2,944 were fitted with the "pail closet," used by 11,770 persons. In 1874 the number of houses so fitted was 7,287, used by 43,500 persons. By the addition of ashes or dry pulverized earth, these pails can be removed without disagreeable effects, and a disinfected pail substituted. Under the old privy system, in Rochdale, the cost of removing the excrement of one thousand persons was £71 a year. Under the "pail closet" system it was £19; the resulting manure selling for three fourths the cost of collecting and preparing it. The very great advantages of this system are apparent.*

The Manchester Corporation closet is much on the same principle, with an arrangement to apply the sifted ashes as an absorbent. The workings of both of these systems were carefully inspected, and reported favorably on, by competent officers of the British Boards of Health; the Rochdale system having the preference on account of its greater simplicity. The excrement from both systems, when removed, is composted into a marketable manure. Either of these systems could be applied to the closets now in use in this country. It would be preferable to project the roof, making a shed under which ashes or earth could be kept dry, to be thrown into the pail whenever the contents should become offensive. The addition of a very small amount of dry powdered loam will instantly absorb all unpleasant odors in a privy on top of the ground. This same effect could be produced in the pails, if drainage from the bottom of the pail be provided, so that the contents be kept as dry as possible. By draining around the closet, so that the earth under it be kept dry, the liquid from the pail will be absorbed. The earth underneath might be removed for several inches in depth once a year, and replaced by fresh earth.

The superior properties of dry earth as an absorbent and disinfectant have been abundantly demonstrated. The loam of the Loess from the upper part of the Hickman bluffs is peculiarly adapted to this purpose; having high absorbent properties, being finely pulverized, and can in all

* Illustrations of these closets will be furnished from this office to any one desiring to test their merits.

weathers be collected dry from the lower portion of the overhanging bluff above the town. The high percentage of lime adds to its value as a disinfectant. Every family can, at nominal expense, be provided at all times with this loam, kept dry and ready for use, which will render harmless and inoffensive any closet in the place. If to this the pail system is added to facilitate removal, a great gain in cleanliness and comfort will be the result.

It is well known that malarial fevers are sometimes prevalent in the Mississippi river "bottoms," and a few suggestions may not be out of place in this connection, although they are not offered with the belief that they have any bearing on yellow fever. West of Hickman the small creek, heading in the bluffs south of the town, widens into a marshy expanse. Were the waters retained at a constant level, no injurious effects would result. It is only after the summer heat has evaporated the water, and laid bare the decayed vegetation beneath, that malarial diseases result.* Until a system can be provided for keeping the water at one level, or the stream confined to a narrow channel, and the now marshy borders reclaimed by drainage and agriculture, it would be desirable for the health of the town that a skirting of timber, made dense by additional planting, be retained between the marsh and the town. It might not be labor in vain to add to this timber shield a skirting of sunflowers, both here and on the banks of the Bayou du Chien, above Hickman.

Prof. Maury was of the opinion that the planting of a few rows of sunflowers between the Washington Observatory and the marshy banks of the Potomac had saved the inmates of that building from the malarial fevers to which they had previously been subjected. This experiment was tried on the marshy borders of the Oglio, near Pisogne, in Italy, with like results. It is asserted that one of the most malarious districts near Rome has been rendered salubrious by a young plantation of Eucalyptus. Similar results from the planting of this tree are reported from other parts of Italy and from Algeria and Louisiana.

† Marsh quotes from Becquerel's "*Des Climates:*" "It has been observed that humid air, charged with miasmata, is deprived of them in passing through the forest. Rigaud de Lille observed localities in

* I learned of a striking instance in proof of this while in Western Kentucky in the autumn of 1877. I was told by a gentleman who had formerly lived on the borders of a large pond, ten acres or more, that, fearing malaria from the same, it being covered with a green scum, he drained it in midsummer, by cutting a trench—the work of a few hours; directly, within a few days, every member of his family was attacked with malarial fever. Previous to the draining, their health had been good

† In his great work: "The Earth as Modified by Human Action" (New York, 1877).

Italy where the interposition of a screen of trees preserved everything beyond it, while the unprotected grounds were subjected to fevers."

The felling of a wood which had long stood between the village of Palo in Italy, and a malarious district south of it, was followed by wide-spread fevers in the village, which had previously been exempted from them. Similar phenomena have been observed in other parts of Italy.* Dr. Metcalf, in his report to the United States Sanitary Commission, says of malaria:

"5th. It has an affinity for dense foliage, which has the power of accumulating it when lying in the course of winds blowing from malarious localities.

"6th. Forests, or even woods, have the power of obstructing and preventing its transmission under these circumstances."

Other authorities might be cited, which the scope of this Report precludes.

The influence of the sun upon well-drained ground cannot be other than salutary; but I would recommend that, until the open squares, described on page 68, be drained, they be planted with some rapid-growing plants. This will not only shield the decayed vegetation from the effects of the sun, but it will be a means of drying those squares. The quantity of water taken up and exuded by some plants is remarkable. For this purpose the sunflower would be a good selection. "A branch of *helianthus annuus* (sunflower), placed in a carafe full of water, and exposed to the sun, exhausts the water very rapidly."†

Dr. Asa Gray says: "The quantity of water exhaled from the leaves during active vegetation is very great. In one of the well-known experiments of Hales, a sunflower three and a half feet high, with a surface of 5,616 square inches exposed to the air, was found to perspire at the rate of twenty to thirty ounces avoirdupois every twelve hours, or seventeen times more than a man."

I believe the caving in of the river banks in the spring, thus baring to the rays of the summer sun the decayed vegetation so abundant on the alluvial banks of the Mississippi, may be a cause of malaria. Of the numerous suggestions to guard against this, I think the most inexpensive, and at the same time the most effective, would be to construct rafts of cottonwood, or other cheap timbers; load these rafts with stone, and anchor them into the quicksand at low water, wherever the river

* Other instances are given in F. B Hough's "Report on Forestry," Washington, 1877.

† Marshal Villant, quoted by J. Crombe Browne "*Forests and Moisture*," Edinburgh, 1877.

impinges against the bank. Where I have noticed the banks of this river there is an unstable, semi-fluid quicksand at low water. The current is constantly cutting into this, which causes the overhanging banks to fall: then the process is repeated. The rafts embedded in the quicksand, taking the slope of the bank, would offer a barrier, and prevent the cutting under of the river. If, in addition, willows were planted and cared for, and long-root grasses adapted to such soil, a bank which would resist the encroachments of the river might be the result.

I have made the above suggestions, believing that the execution of such a system of sanitary reform would promote the healthfulness of the town. That it will have any effect in preventing a recurrence of yellow fever, or in moderating its virulence, I do not venture to assert.

As a means of preventing a recurrence, I have but one recommendation to make, which is, I believe, the one universally agreed upon—a rigid quarantine, allowing no boat from an infected district to come within five hundred yards of the shore, and compelling all railway cars from roads running through such districts to stop outside of the town limits. The most, and probably the only, successful mode of combating this fever, after it has made its appearance in a place, is by depopulating the place, and scattering the inhabitants throughout the country. By the use of freight cars as temporary houses, and the tents and camp outfit belonging to the Quarter-Master's Department of the State, a town the size of Hickman could be depopulated in a few days, and the people cared for in small camps until such as could afford it could seek accommodations in towns and farm-houses.

When yellow fever invades a State, I see no reason why it should not be declared a public enemy; and, if necessary, arbitrary measures taken to combat it.

I regret that the scope of this Report precludes me from sufficiently expressing my admiration for the men who have brightened the otherwise all-pervading gloom of this epidemic by their heroic philanthropy. We justly admire our military heroes, but we should remember that such admiration for warlike fame is the remnants of the savagry which centuries of civilization have not yet eliminated from our race, and that a higher heroism is theirs who go into the Valley of Death with no blare of trumpets nor flaunting of banners, and battle with an unseen foe. No page in Kentucky history will be brighter than that recording the story of the Heroes of Hickman.

APPENDIX A.

CHEMICAL LABORATORY KENTUCKY GEOLOGICAL SURVEY,
LEXINGTON, KY., January 20, 1879.

Jno. R. Procter, Esq.:

DEAR SIR: I have examined the four samples of cistern water from the city of Hickman, Fulton county, Kentucky, sent by you to the laboratory for analysis, and now give you the results.

Sample 1.—Labled "Water from Cistern (21), in plot of Hickman;" * contained in a green pocket-flask; cork not tight; smelt of rotten wood, and was of a decided light-brownish color.

Sample 2—"Water from Cistern (22), plot of Hickman," &c., in white, quart pocket-flask, with a common cork; smelt strongly of rotten wood, and was also of a decided light brownish color.

Sample 3.—"Water from Cistern (28), plot of Hickman," &c.; also contained in a flat, white pocket-flask, with common cork; smelt also of rotten wood, and was of a light-brownish color.

Sample 4.—"Water from Cistern (25), plot of Hickman," &c.; in a green, flat patent-medicine flask; with common cork; had *no color*, and only a slight odor of camphor—doubtless derived from the bottle.

Each of these waters gave a slight *alkaline reaction*, both in the original water and in the solid saline residue obtained by evaporation. Evaporated to dryness, these waters gave of solid *saline residue*, dried at 212° F., to the 1000 *parts*, the following stated quantities, viz:

No. 1 gave 0.84 of a light-brownish tint.
No. 2 gave 0 87 of a light-brownish tint.
No 3 gave 0 44 of a light-brownish tint.
No. 4 gave 0 47 perfectly white.

Qualitatively tested for *nitrates* and *nitrites:*

No. 1 gave a decided reaction.
No. 2 gave a slight reaction.
No. 3 gave a decided reaction.
No. 4 no reaction.

Distilled with the addition of ignited sodium carbonate, until about one third passed over, the distillate being received in diluted chlorohydric acid, and the resulting ammonia estimated as chloride of platinum and ammonium, the several waters gave the following result, as calculated in the *million parts* of the water:

(* See Plate I.)

No. 1 gave 1.2 parts of ammonia to the million.
No. 2 gave 3.63 parts of ammonia to the million.
No. 3 gave .60 parts of ammonia to the million.
No. 4 gave .60 parts of ammonia to the million.

The residue in the retort was again distilled, after an addition of caustic soda and potassium per-manganate, the object of which is to convert into ammonia the combined nitrogen of any organic compound present which may have resisted the action of the sodium carbonate. The result was as follows:

No. 1 gave 1.45 parts of albuminoid ammonia to the million of the water.
No 2 gave .45 parts of albuminoid ammonia to the million of the water.
No. 3 gave .97 parts of albuminoid ammonia to the million of the water.
No. 4 gave .73 parts of albuminoid ammonia to the million of the water.

The waters, caustic soda having been added, were then titrated with a normal solution of potassium manganate; to ascertain how much oxygen was required to *oxidate the organic matters* they severally contained, the following results were obtained:

No. 1 required 35.2 parts of oxygen to the million of water.
No. 2 required 20.8 parts of oxygen to the million of water.
No. 3 required 13 6 parts of oxygen to the million of water
No. 4 required 1.6 parts of oxygen to the million of water.

As a sufficient quantity of the waters had not been supplied for complete *quantitative* analysis, they were simply *tested* for their saline ingredients, with the following results:

	Chlorine.	Sulphuric acid.	Lime.	Magnesia.	Iron.	Phosphoric acid.
No. 1.	much.	much.	considerable.	little.	trace.	a marked trace.
No. 2.	do.	do.	do.	do.	do.	not tested.
No. 3.	do.	do.	do.	do.	do	a marked trace.
No. 5.	trace.	trace.	do.	do.	none.	not tested.

It is evident, from these experiments, that waters Nos. 1, 2, and 3 give decided evidence of containing impure materials, probably derived from the infiltration of city drainage into the cisterns (21), (22), and (28); while the water of cistern (25), measurably free from this contamination, gave 0.73 per million of albuminoid ammonia. It also contains *saline matters* which may have been derived from the surrounding subsoil, by influx of surface spring waters or otherwise. These saline matters, however, are not at all injurious to health; but the organic and other nitrogenous materials, derived from drainage, although taken into the animal body in very small quantities at a time, are found, by experience, not only to induce grave disorders of the system, but greatly to increase the mortality of existing epidemics when habitually taken in the daily drink.

According to the experiments of many skilled observers, rain-water always contains more or less ammonia, as well as nitrates and nitrites. Organic matters, also, in the form of microscopic spores and dust, are always to be found in the atmosphere at ordinary levels. These ingredients, which are in larger proportion in cities than in the open country, are brought down continually in the rain and snow which fall through the atmosphere.

Boussingault found in recent snow-water, in the country, only 0.17 part of ammonia in a *million;* in rain-water in the country 0.79; in rain-water in Paris, 4.00; while Bineau found in rain-water which fell in the city of Lyons, 16. parts in the million.

Indeed, the water which falls in large and crowded cities has been found to be unsafe in hot weather, because of its contamination with organic matters; and experience has led to the conclusion, that any water which contains more than 0.15 part of "albuminoid nitrogen" to the million is unfit for drinking.

Now, on reference to the preceding statements, it will be seen that all these four waters gave a notable quantity of "albuminoid ammonia;" and when we calculate the amount of nitrogen contained, we shall see that even the water No. 4 holds much more than is said to be compatible with safety in drinking water; thus:

Water No. 1 contains 1.20 parts of nitrogen per million.
Water No. 2 contains .37 parts of nitrogen per million.
Water No. 3 contains .80 parts of nitrogen per million.
Water No. 4 contains .60 parts of nitrogen per million.

Another circumstance pointing to drainage contamination is, that waters Nos. 1, 2, and 3 contain a large proportion of chlorine compound

All things considered, although the limit of safety in drinking water, fixed at 0.15 of albuminoid nitrogen to the million, may have been much misplaced toward the safe side, yet it seems evident that at least three of these waters, Nos. 1, 2, and 3, are too much contaminated to be wholesome; and further, it is very probable that they may, by continued use, not only cause disease, in hot weather especially, but greatly increase mortality in times of epidemics or endemics.

Yours, &c., ROBERT PETER.

APPENDIX B.

TABULATED Statement of Boats Going North from New Orleans, During the Prevalence of Yellow Fever.

Name of Boat Leaving N. O.	New Orleans.				Vicksburg.					Memphis.					Cairo.				
	Date of Departure.	Temperature.	Barometer.	State of Weather.	Date of Arrival.	Temperature.	Wind. Direction from.	Barometer.	State of Weather.	Date of Arrival.	Temperature.	Wind Direction from.	Barometer.	State of Weather.	Date of Arrival.	Temperature.	Wind. Direction from.	Barometer.	State of Weather.
John D. Porter and barges (1) . .	July 18	87°	29.91	Fair.	July 24(2)	97°	N.	29.98	Fair.	. . . . .	. . .	. . .	. . .	. . .	July 29(3)	82°	N. E.	29 85	Fair.
Commonwealth	July 24	92°	29.93	Rain	July 26 .	94°	S. W.	29.86	Cl'dy	July 29(4)	87°	N. W.	29.87	Fair.	. . . . .	. . .	. . .	. . .	. . .
Golden Crown (5)	July 27	92°	. . .	Cl'dy	July 30 .	98°	N.	. . .	Fair.	Aug. 1 .	96°	S. W.	29.83	Fair.	Aug. 4(6)	90°	W.	29.84	Fair.
Golden Rule (7)	Aug. 10	87°	. . .	Cl'dy	Aug. 12 .	85°	N. E.	29.92	Cl'dy	. . . . .	. . .	. . .	. . .	. . .	Aug.16(7)	89°	S. E.	30.01	Fair.
John Gillmore	July 29	93°	29.89	Fair.	. . . . .	. . .	. . .	. . .	. . .	Aug. 5 .	92°	. . .	. . .	. . .	Aug. 6 .	91°	W.	29.89	Fair.
John A. Scudder.	. . . .	. . .	. . .	. . .	. . . . .	. . .	. . .	. . .	. . .	Aug. 8(8)	95°	S.	29.91	Fair.	(9)	. . .	. . .	. . .	. . .

NOTES TO TABLES IN APPENDIX B.

(1.) The John D. Porter arrived at New Orleans July 16th, and remained until the 18th, several days after the yellow fever had appeared in that place. Fever made its appearance among the crew as early as the 19th. See history of the Jno. D. Porter, and the cases of fever on board. Dr. Minor's Report on "Yellow Fever in Ohio."

(2.) Courier-Journal River News, July 29: "The John Porter and tow from New Orleans passed Helena Saturday evening (July 27th), with a canvas over her name. It is reported she had several cases of yellow fever aboard."

(3.) Cairo Bulletin, August 1, has the following: "The long-looked for and much-dreaded John Porter, which has been reported a floating pest-house, came up from New Orleans. The tug met her at the mouth of the river, and our city fathers and medical adviser boarded her, and found her in a healthy condition. They gave her permission to land, and so ends the much talked of yellow fever scare."

The Porter remained at Cairo until August 1.

(4.) "The Commonwealth, in passing Memphis, put off two men that were sick. The swamp or malarial fever is doing its work among the lower river boat crews."

(5.) Golden Crown arrived at New Orleans night of July 23, where she remained until the afternoon of the 27th.

Impossible to arrive at the number of deaths to this date, as the facts were concealed at the time. The report of the Louisiana Board of Health for 1879, gives the total deaths in July at twenty-six.

(6.) Courier-Journal River News, Louisville, August 9th: "The Golden Crown and two barges passed up from New Orleans yesterday. No 'yellow jack' aboard."

(7.) The Golden Rule arrived at New Orleans, August 9th, and departed next day. The yellow fever had been epidemic in that city for almost a month previous to this date, as will be seen by the reports of the Louisiana State Board of Health.

The Golden Rule landed at the foot of Fourth street, Louisville, August 19th, at 1 P. M. Was boarded by the Mayor and Health Officer of Louisville, who reported three men prostrated with intermittent fever. The sick on the boat were also examined by surgeons from the U. S. Marine Hospital, who pronounced the cases intermittent fever.

The Mayor prevented the unloading of freight from the boat. Range of thermometer from 7 A. M. until 10.25 P. M., that day, 82°, 92°, 95°, 94°, 78°, 77°; weather cloudy; wind S. and S. W.; brisk.

The Golden Rule reached Cincinnati quarantine station August 20. Six cases from the boat were admitted to the yellow fever hospital at Cincinnati; all of them pronounced to be yellow fever by Dr. Minor, Health Officer of Cincinnati. See report of these cases in Dr. Minor's report on "Yellow Fever in Ohio," pages 45, 46, and 47.

(8.) "John A. Scudder, from New Orleans to St. Louis. Owing to sickness on board, the Captain refused to take passengers at Memphis."

(9.) Scudder did not land at Cairo. I do not know whether she landed at Hickman; must have passed there on the morning of Aug. 9.

In addition to the boats given in the tabulated statement, the following passed north from New Orleans, and one or more may have landed at Hickman:

The Port Eads and barges passed Vicksburg July 25th, and again, on second trip, August 15th.

Gold Dust passed Memphis night of August 5th.

Paris C Brown passed Memphis August 8th.

Grand Lake and barges left New Orleans for St. Louis August 6th.

Belle of Shreveport left New Orleans for St. Louis August 7th.

The John D. Porter arrived at the foot of the canal below Louisville on August 12th, and remained at the mouth of the canal all day, and passed through at midnight, landing at the foot of Sixth street. A man (Mike Mohannan) attempted to prevent the boat from landing; failing in his attempts, he ran to the Central Police Station and demanded the Health Officer; was informed by the Station Keeper that the Health Officer could not be found at that time of night, and that nothing could be done. It was not known how long the Porter remained at Louisville, as no notice of her departure was given. At this time eleven of the crew were reported to have had the disease, four of whom had died. Some of the crew became alarmed, and left the boat at Louisville, and new men were hired in their places. The following meteorological record, from the U. S. Signal Service reports, may be of interest in this connection:

METEOROLOGICAL RECORD, LOUISVILLE, KY.

Time of Observation.	Thermometer.	Barometer (corrected readings).	Relative humidity.	Wind. Direction of.	Velocity miles per hour.	State of weather.
August 12—7 A M . .	71	29.964	71	N.	6	Clear.
11:25 A. M . .	82	29.931	39	N. W.	5	Hazy.
2:00 P. M . .	86	29.892	33	N. W.	6	Hazy.
4 00 P M . .	85	29.848	38	N. W.	6	Fair.
9 00 P M . .	78	29.871	57	N. W.	1	Fair
10:25 P. M . .	76	29.879	56	N. W.	4	Clear.
August 13—7 A. M . .	71	29.877	66	N.	6	Hazy.
11:25 A. M . .	84	29.860	37	N.	5	Fair.
2:00 P. M . .	85	29.826	32	N. W.	5	Clear.
4:00 P. M . .	86	29.774	30	N. W.	5	Clear.
9 00 P. M . .	78	29.827	57	N. W.	2	Clear.
10:25 P. M . .	75	29.839	64	N. W.	1	Clear.

August 14 Thermometer for same hours was: 72°, 84°, 88°, 88°, 74°, 73°.
August 15. Thermometer for same hours was: 72°, 88°, 89°, 88°, 76°, 74°.
August 16 Thermometer for same hours was: 79°, 88°, 90°, 92°, 83°, 80°.

STATEMENT

Showing the Mean Monthly Temperature, Mean Monthly Barometer, and Total Amount of Precipitation, which fell at Cairo, Ill., during the months of June, July, August, and September, 1878, as recorded at the Station of Observation of the Signal Service U. S. A., in that city, compiled from the records on file at the office of the Chief Signal Officer U. S. A., at Washington, D. C.

1878.	Cairo, Ill.				
				Wind.	
	Mean Temperature.	* Mean Barometer.	Amount of Rainfall in inches.	Prevailing direction during month	Number of miles traveled during the month.
June	76.4	29.949	4.61	S.	4,402
July	83.7	29.969	2.81	N.	3,207
August	82.1	29.924	3.45	S. W.	3,822
September	72.0	30.022	2.95	S.	5,197

* Corrected for temperature, instrumental error, and elevation

War Department,
Office of Chief Signal Officer,
Washington, D. C.